



February 28, 1980

TO: Daryl Domning, Hildegard Howard, Richard Huddleston,
Charles Repenning, and Bruce Welton

SUBJECT: OUR SAME OLD LATE MIOCENE PAPER!

Firstly, you will notice that I've invited Bruce Welton on board to help with sharks and fish.

Secondly, note Mike Woodburne's letter. He's personally re-assured me he didn't want to discourage; but he wants a finished m.s. soon.

I've redone the outline of the manuscript. You are receiving a copy of a new cut and pasted typescript. Note that not all rock units need to be treated in the same manner. I've lifted some pertinent data from our various notes, letters, and recent publications, and dropped them into the m.s. under their appropriate rock units. I've already pretty much collated the Sisquoc data. What I really need help on now is for Daryl to similarly edit the data on the Tejon Hills and Towsley Formation down to good text, and for Rep to do likewise on the Scotts Valley and Cammatti Ranch sections. We here at L.A. will work on the Modelo, Monterey, and Puente Formations, the tables, and figures.

I'd like to get this all ready for final typescript in a couple of weeks elapsed time; really! Any suggestions on the final format for our correlation chart also.

Let's get it done this time!!

Sincerely,

Lawrence G. Barnes
(LGB)

Lawrence G. Barnes
Curator
Vertebrate Paleontology

LGB/sab

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DEPARTMENT OF EARTH SCIENCES
Geography — Geology — Geophysics

RIVERSIDE, CALIFORNIA 92521

February 12, 1980

Dr. Larry Barnes
Department of Vertebrate Paleontology
Natural History Museum
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Los Angeles, CA 90007

Dr. C. A. Repenning
U. S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

Dear Larry and Rep.,

Some comments on your "Miocene" sea mammal paper. The point has been made to me that 1) Savage, 1955 adequately showed the relation of the "Margaritan" "Stage" to the land mammal chronology; there already exist demonstrations or means thereto to show the relationships between the marine invertebrate, both macro and micro, "stages." Why do we need another one? Marine mammals occur in marine rocks, already well characterized. Your introduction needs a strong justification.

Similarly, even a strong justification loses some force, perhaps a lot, when you say you are only trying to show that it is possible to make a zonation based on marine vertebrates, but don't actually do it. Does this mean that you think the case is weak for such a proposal?

Your un-named stage is a temporal correlative of, etc. Correlative of all of the Clarendonian, the "Margaritan" and the Mohnian and Delmontian. You nowhere give a detailed justification for any of these statements, unless and except a reader knows enough to read Savage 1955 and Repenning and Vedder, 1961, etc., etc.

Your claim that your units are recognizable and definable is not compelling. You detail no ways to support a definition (setting limits).

Some consistency is needed. You alternatively correlate the "Jacalitos" with the Miocene and Pliocene.

The first 3 pages on Sisquoc formation should be boiled way down, to end with your paragraph on the 4th page. The next page starts out talking about age, then digresses to first naming of the formation. The latter should come at the beginning of the whole section, etc.

p. 8. The Sisquoc Formation is widespread..... It is usually called late Miocene to early Pliocene, etc. This also should come before pages 5-7.

Notes to myself:

Next pages detail collecting sites, etc. of various vertebrates.

Then Santa Margarita Frm. This section is better organized.

Towsley Formation. OK

Modelo Formation. OK; same for Monterey. Is Tepusquet Canyon really worth noting? *yes. Type loc. of Osteodontornis.*

Capistrano Syncline: Best loc is no longer available for inspection. Generally rambling; no clear intent of points to be made. *OK. LCB*

Valmonte Diatomite

Puente Formation

Conclusions: "There is thus...." This statement is not warranted by the preceeding. The general presentation is very unorganized, no or little orienting remarks are given as we go along to orient the reader. Presentation should be made much more efficiently. *OK*

207 { What you are doing, of course, is to demonstrate the repetitive stratigraphic associations of the vertebrate taxa with either marine invertebrate or nonmarine mammal forms to support your interpretation that the marine vert. association is time significant. This, then, justifies your formation, or unit-by-unit discussion, provenance of specimens, validity of stratigraphic associations, and the like. These reasons are not clearly stated. No overall philosophy or methodology is given. Without them the reader gets lost in a hurry.

I propose that you provide the above and then that these sections be standardized as follows:

5 { Formation Unit Name. Brief history of naming; areas distribution; pertinent aspects of physical relationships to other important units. Marine Vertebrates. composition, standardized, with sub-heads. Sharks. Birds. Mammals. - with pertinent comments as to provenance, i.e., "most of the taxa have relatively poor stratigraphic data, but the most important, or best, situations are....."

Follow this with Relations To Other Chronologies. Detail those situations that demonstrate the interrelationships to marine micro or megafossil, land mammal chronologic systems, the degree of comparability, overlap, etc.

Age. This section could be quite brief. Based on the above, what you think here should follow fairly easily, regardless of past conventions. You could get by with a list of important previous authors and their age interpretations, if even that much is necessary.

Larry Barnes
C. A. Repenning

-3-

February 12, 1980

In such cases where not all of the above is possible or justified, that rock unit could be dispensed with quickly.

Now. Why have you done all this? What have you gained? What important relationships can be shown by the above analysis that were lacking formerly. The science should be advanced to some extent by your work. Other than having another potential chronological scheme and nomenclature, what else can you do. I think the readership deserves to know why it should think your work is important. Without a better and more tightly organized piece of work I am not convinced that this subject is worth publishing. Please don't misunderstand that statement. Basically I am sure that this subject is worth publishing, but not at the level of clarity - organization presented here. Please think carefully about what you want to do, and let me have a revised manuscript, completely paginated, fully typed consistently, and completely illustrated as soon as possible.

Sincerely,

Mike

M. O. Woodburne

MOW/cc

Correlation and Characterization of Late Miocene (Clarendonian
Correlative) Marine Vertebrate Assemblages in California.¹

For:

Proceedings of the Society of Vertebrate Paleontology Symposium in
Dallas, Texas, on November 14, 1973, prepared by a Committee on Cenozoic
Marine Vertebrates.

Lawrence G. Barnes² (Chairman), Daryl P. Domning,³ Hildegard Howard,²
Richard W. Huddleston,⁴ Charles A. Repenning,⁵ and Bruce J. Welton.²

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4. Chevron Research Lab - etc.

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ABSTRACT

004

Fossil localities which produce late Miocene marine vertebrate assemblages in California are numerous and widespread. Rocks containing these assemblages are commonly called late Miocene or early Pliocene in the previously published literature and are correlated with the Clarendonian^{North American} mammal age, the provisional "Margaritan" mega-invertebrate stage, and the Mohnian and Delmontian^{west coast benthonic} foraminiferal stages. The characterizing marine vertebrates of this time are sharks: Galeocerdo aduncus, Isurus planus, Isurus hastalis, Hemipristis serra, Carcharodon megalodon, Carcharhinus, and Echinorhinus; teleosts, Smilodonichthys, Xyne grex, Chauliodus eximius; birds: Puffinus diatomicus, Osteodontornis orri, Morus lompocanus, Sula willetti, and Praemancalla lagunensis; and mammals: Nannocetus eremus, aff. Pithanodelphis sp. nov., Pithanotaria starri, Imagotaria downsi, Desmostylus hesperus, Paleoparadoxia tabatai, and Dusisiren jordani. At least three of the above taxa, and in most cases several, are found at each of the following localities or districts: Scotts Valley, Santa Cruz County (Santa Margarita Formation); Lompoc Quarries, Santa Barbara County (Sisquoc Formation); Tejon Hills, Kern County (Santa Margarita Formation); Newhall-Saugus area, Los Angeles County (Towsley Formation); Santa Monica Mountains, Los Angeles County (Modelo Formation); Laguna Hills, Orange County (Monterey Formation); Tepusquet Canyon, Santa Barbara County (Monterey Formation); San Gabriel Valley, Los Angeles County (Puente Formation); and Palos Verdes Peninsula, Los Angeles County (Valmonte Diatomite).

of the taxa above listed
only one (not three) occurs
in Tepusquet Canyon (Osterodontianis)
unless you have other records
I don't know of. There are
3 species of birds from Tepusquet
but they are not listed above"
HH

with some

faunal assemblages of ^{fossil} marine vertebrates ^{that coincide} with some chronostratigraphic units of stage-age magnitude are recognizable and definable in the Neogene ^{marine} deposits of the Pacific coast of North America.

^{we} ^{herein} provide an example: ^{Late Miocene} the ^{marine} vertebrate faunal unit that existed ^{from} about 10 to 13 million years ago, and is an ^{approximate} temporal correlative of the Clarendonian North American ^(Addicott, 1972) of ^{Age, of} the "Margaritan" west coast mega-invertebrate stage, and ^{part of the} the Mohnian and Delmontian west coast benthic foraminiferal stages. We do not now propose the ^{formal} naming or establishment of sequences of marine vertebrate stages but point out that knowledge of fossil marine vertebrates has advanced to the point where they are useful in correlation. ^{Some} geologic, evolutionary, or zoogeographic phenomena may

separate the Clarendonian-equivalent marine vertebrate assemblage from previous ^{and} successive assemblages, and ^{aggregate} some transitional taxa have been noted, but the ^{aggregate} late Miocene marine vertebrate ^{assemblage we define} is distinct from earlier and later such assemblages.

The characterizing aggregate assemblage

We present ^{includes} the dominant and diagnostic marine vertebrates known to have lived during the above-stated time span on the coast of California. Most ^{collecting have fossil} sites that produced these vertebrates can be correlated with at least one of the ^{previously} established stages based on terrestrial mammals, marine invertebrates, or foraminifera. Correlations with the ^{ing} mammal ages are probably the most straightforward and in certain ways the least controversial. They also provide a method of correlating with the radiometric time scale.

Our concept of the "Margaritan" stage, follows ^{ing} Corey (1954) and Addicott (1972),

is that the "Margaritan" is a late Miocene chronologic unit based upon ^{certain} marine mollusks and echinoderms, and includes the more restricted Briones, Cierbo, and Neroly stages ^{recognized by earlier workers.} We quote ^{some other workers'} correlations with the

Mohnian and Delmontian foraminiferal stages but ^{the reader should bear in mind that} there is some ^{controversy} ^{over} of whether these are separate or overlapping. ^{Some} ~~Many~~ of the vertebrate fossils to which we refer are unnamed or ^{otherwise previously} undocumented in the paleontologic literature, but are the basis of ^{of some of the important taxa} ongoing research by the contributors to this report.

¹⁹⁷⁸ published records ^{have been} by Howard (1957, 1962, 1966, 1968; ¹⁹⁷⁸ Howard and White (1962; Miller (1925; Mitchell (1968; Kellogg (1922, 1925, 1929); Barnes (1971; ^{1976, 1978} Mitchell and Repenning (1963; ^{Repenning and Tedford (1977)} Domning 1972; ¹⁹⁷⁸ Savage and Barnes (1972; Downs (1955; and Lyon (1941).

Figure ^{marine} ~~★~~ indicates some of the districts in California where ^{important fossil} rocks have produced ^{localities} vertebrates of this age. Some of these are well known and have produced terrestrial vertebrates of Clarendonian age but are mentioned only briefly here if marine vertebrates are rare. One such example is the Commatti Ranch site in the Santa Margarita Formation in San Luis Obispo County. ^{Important} localities are in Scotts Valley near Santa Cruz, in the diatomite quarries near Lompoc, in the Tejon Hills near Arvin, in the San Gabriel Mountains near Newhall, on the north flank of the Santa Monica Mountains, and in ^{the} Laguna Hills near El Toro and Laguna Niguel.

The marine vertebrate assemblages ^{and} / their content and context are discussed in the following text by formation. ↑ This system seems most logical and provides a geographic and geologic background for the faunal discussions. Each formation is discussed in terms of its nomenclature, areas of outcrop, marine vertebrate fossil content, chronology, and age.

The Sisquoc Formation is discussed first because it produced the type specimens of ^{marine} ~~many~~ taxa that are characteristic of the time interval.

?
mana?
H

ACKNOWLEDGMENTS

Alphabetically

Shelton P. Applegate

Mitchell

Johnson

Calhoun

McKenzie

Lauenberg

Morejohn

Price family

Don Fife

ABBREVIATIONS

The following abbreviations are used in the text to denote institutions housing fossil specimens:

LACM - Natural History Museum of Los Angeles County, Section of Vertebrate Paleontology

UCLA - Paleontological collection in the Department of Biology, University of California, Los Angeles *Paleo?*

UCMP - University of California Museum of Paleontology, Berkeley

CIT - California Institute of Technology, collections and files now held by Natural History Museum of Los Angeles County

SBMNH- Santa Barbara Museum of Natural History.

R CAS - California Academy of Sciences.

? USNM - United States Nat Mus

SISQUOC FORMATION

No 91

Distribution and Nomenclature

County, California exposed ¶ The Sisquoc Formation was named by Porter (1932) for rocks in Santa Barbara County, California ^{the town of} to the north of Lompoc in the Purisima Hills. ^{The same name} has since been applied to ^(Wright, Cheslerman, and Norman, 1954:73; Barron, 1975:--) the Lompoc Hills or "White Hills" ^{in 1936 they} ^{had been} assigned ^{exposures of diatomite south of Lompoc in} to the Monterey Formation by Mulryan (p. 137, 139).

The sequence of diatomites is approximately 1000 feet thick (Mulryan, 1936: 139; Dibblee, 1950:75-77), and may represent a significant period of time (Barron, 1976).

As interpreted in subsequent geologic mapping projects ^{now recognized as being}

¶ The Sisquoc Formation is widespread in Santa Barbara County (Dibblee, 1950; Woodring and Bramlett, 1950).

¶ There are some inconsistencies in the literature regarding the distinctions between the Sisquoc and Monterey Formations. Woodring and Bramlett (1950:26) were ^{equivocal} in placing the boundary between these two rock units, indicating that the Sisquoc does not have uniform lithology nor uniform relationships with the underlying Monterey. They put the contact (p.23) at the first thick claystone horizon, which however is above some siltstone strata which are possibly equivalent to the diatomite and diatomaceous shale in the lower part of the Sisquoc Formation in Purisima Hills. The formation is divided into the Todos Santos Mudstone Member which is a fine grained basin facies that includes the diatomaceous mudstone and porcellaneous mudstone, and the Tinaquaik Sandstone Member which is a marginal facies in the northeastern area of outcrop (Woodring and Bramlett, 1950:26).

Sisquoc formation, and in particular the

(91) The ^{exposed} diatomaceous sediments in the Lompoc Hills ^{present study because} south of Lompoc are important in the ^{they} have produced many important marine vertebrate fossils. for over fifty years they These fossils include specimens of fish, birds, and mammals, many of which were designated as holotypes of species that we now consider characteristic of the late Miocene marine vertebrate assemblage.

vertebrate resulting scientific literature ^{have} form ^{ed} the basis for comparisons ^{these specimens and the} ^{with other} fossil marine assemblages of late Miocene age ^{our} California.

however,
Except for the most recently collected specimens, ^{position of the} there is no dependable biostratigraphic data for the ^{within the Sisquoc Formation} important type specimens of birds, fishes, and mammals. Such information could possibly be gleaned by merging Kellogg's locality data with early quarry development data (cf. Mulryan, 1936), and with microfossil analysis of matrix with specimens.

Quarry operators have recently devised codes used to label ~~desirable~~ commercially desirable diatomite beds, and we have discovered several ash beds that could be analyzed.

(9)

vertebrate

Virtually all of the ^{vertebrate} fossils from the Sisquoc Formation have been discovered incidental to commercial quarrying operations for diatomite. Diatomite was first removed from the ^{Lompoc} Hills in the late 1880's, and an assortment of individuals and ^{small} companies continued quarries until 1928 (Mulryan, 1936:134-136), when the present ^{operators of many of the quarries south of Lompoc} the Johns-Manville Corporation, acquired the ~~quarry~~ properties.

The bird specimens described by Miller (1925) were obtained by David Starr Jordan during his studies of fossil fishes from the diatomites. ← All of the mammal specimens described by Kellogg (1922, 1925a, b) and a skull by Mitchell (1968:1866) were collected from 1919 to 1926 from the quarries between San Miguelito Creek and Salsipuedes Creek in Lompoc Hills which were being operated by the Celite Products Company prior to its sale to the Johns-Manville Products Corporation in 1928 (Mulryan, 1936:136).

4

By 1936 Mulryan (p. 151) reported that "numerous whales have been found", including a toothed whale whose "longest tooth was three and one-half inches" long. ^{from Lompoc, the holotype of *Megaptera miccaena* Kellogg, 1922,} Only one whale specimen had been described in the ^{scientific} literature by that date, and the ^{subsequent} disposition of these additional specimens mentioned by Mulryan is unknown. There ensued an apparent gap in the retrieval of fossils from the diatomite ^{quarries} until the 1950's when some specimens were placed in the Santa Barbara Museum of Natural History (Orr, ^{P.} 1954).

5

During World War II the Dicalite Division of the Great Lakes Carbon Corporation started a quarry on Rancho San Julian, 7 miles southeast of Lompoc (Wright, Chesterman, and Norman, 1954: 69, 73), and

this quarry was the source of the ^{of *Imagotaria downsi*, a pinniped} holotype described by Mitchell (1968: 1868-1869).

← In the late 1960's the Dicalite Division began quarrying closer to Lompoc, on the westside of San Miguelito Creek, and numerous specimens ^{(principally LACM).} are now being obtained for museum collections. None of these recently collected ^{fish,} mammals, or birds have yet been studied ^{in detail,} however.

Marine Vertebrate FossilsTeleosts.

Gilbert (1910) described the first teleost from the diatomite beds at Lompoc. During the period from 1919-1927 the Lompoc ichthyofauna was extensively studied (Jordan, 1921, 1924, 1925, 1927; Jordan and Gilbert 1919, 1920). Between 1927 and 1943 there was a hiatus in the study of the Lompoc fishes. David (1943) re-examined Jordan and Gilbert's material and revised the fauna.

Single families have been studied, Syngnathidae-pipefishes, Fritzsche (ms), and Xyne grex, Zawacki (1974)

LAREX; THIS IS ONLY TENTATIVE
AND I WOULD LIKE TO EXPAND IT
OR AT LEAST REFINE IT
I WILL WRITE BACK TO THE MUSEUM
UNIL REAG. AND SHOULD
HAVE MORE.

RICHARD.

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Copied
March 19, 1980

Sisquoc
Formation

→ Six species of marine birds have been described from the Lompoc
quarries (Miller, 1925). Five of these are ^{known} recorded, at least tenta-
tively, from other Late Miocene formations ^{discussed in the present study.} At least twenty specimens
^{have been recovered from the diatomite quarries} are now ^{known}, many of which are ^{were previously} unrecorded. These specimens are dis-
tributed in the collections of the Museum of Paleontology at the
University of California, Berkeley (UCMP), the California Academy of
Sciences (CAS) and the Natural History Museum of Los Angeles County
(LACM). All ^{but one specimen} except (LACM no. 74069) ~~collected in 1925~~, are in the
form of skeletal imprints in diatomite, with no bones remaining.

In the latter specimen, badly fragmented wing bones are still present.
← Although the skeletal impressions provide ^{data on} an excellent ^{portrayal}
of the ^{body} proportions of the species represented, there is very little
detail of individual elements preserved. Lacking this detail it is
difficult to make comparisons with isolated bone fragments such as
occur in localities in the Orange County, Monterey Formation. The
fact that all but one of these species belong to ^{extant} ~~still-existing~~ genera
increases the difficulty of making significant comparisons.

The one exception, Miosula media Miller, 1925, of the family Sulidae,
is ^{known from} ~~represented in~~ the Sisquoc Formation ^{only} ~~by~~ the obverse and reverse
slabs of the holotype skeleton (UCMP 26543). This lacks the skull,
but is otherwise fairly complete. M. media was a species with large
body and legs, but ^{with} relatively shorter wings and ^a more curved humerus
than ^{species} ~~in living members of the family~~. Miller (1925:115) noted that
the ^{extinct} ~~genus~~ Miosula occupies ^{Sulidae} ~~a position~~ intermediate between the gannets
and the cormorants in its proportions.

Two other species of sulids ^{occur} ~~are represented~~ in the Sisquoc
Formation. The larger ^{of these} Morus lom pocanus (Miller, 1925), is close

in size to the ^{living} ~~present-day~~ Common Gannet, Morus bassanus (Linnaeus, 1758) of the North Atlantic oceans, ^{but} ~~though~~ with longer wings. The holotype (UCMP 26544) and two other specimens of M. lomdocanus (UCMP 117309 and ~~UCMP~~ 115855) were illustrated ^{by} ~~(Miller, 1925: pls. 4, 7b, and 9).~~ A fourth specimen (UCLA 2840) was studied and identified by Miller but ^{never published.} ~~not recorded.~~ The holotype is an incomplete skeletal impression, but the other ^{known} specimens ^{include} ~~supply~~ most of the missing elements, including an incomplete skull.

The third sulid, Sula willetti Miller, 1925, was a smaller bird, said to be approximately the size of the existing Red-footed Booby, but with different ratios of limb ^{elements.} ~~segments.~~ The holotype (UCMP 26542) consists of obverse and reverse slabs containing a nearly complete skeletal impression, including the skull. ^{The holotype and} ~~A second,~~ ^{have been} ~~less complete specimen (UCLA 2839) is figured (Miller, 1925: pl. 8).~~ ^{pl. 3,}

The shearwaters (Family Procellariidae) are represented ^{in the Sisquoc Formation} ~~by~~ a single species, Puffinus diatomicus Miller, 1925, ^{which is} ~~similar~~ in general characters and ⁱⁿ ~~size~~ to the Recent Black-vented Shearwater, but with shorter wings and longer legs. The holotype (UCMP 26541) is a practically complete skeletal impression. This and another equally well preserved specimen, and a cotype wing ^{were} ~~are~~ ^{by} ~~figured~~ ^{Miller,} (1925: pls. 1, 2, ~~and~~ 7a). At least six other specimens of the ^{is} ~~species~~ have been identified from the Sisquoc Formation, only one of which ~~is~~ ^{has been} ~~published~~ ^{recorded} (Orr, 1940). The latter specimen ^{(CAS collections),} ~~was~~ collected in 1938 by G. Dallas Hanna, ~~of the California Academy of Sciences and is in the collections of that institution.~~ It is somewhat smaller than the holotype, but is within a size range comparable to that of the living Black-vented Shearwater.

The other two ~~sea~~ birds described by Miller were each based only on a single slab, ~~holotype~~. For Cerorhinca dubia^a Miller, 1925, the ~~holo~~ this type (UCMP 26546) consists only of the leg bones, said to resemble those of C. monocerata (Packard, 1811), the living Rhinoceros Auklet, though with ^arelatively longer tibiotarsus and ^ashorter tarsometatarsus. Probably also referable to C. dubia is a ^{new} specimen (LACM 74068, ~~collected in 1975 at~~ ^{from} LACM locality 4156) ^{see p. 1020 re this locality} in a diatomite quarry in Miguelito Canyon of the Lompoc Hills. This specimen consists ^{ing} of badly fragmented wing bones ~~in a slab of diatomite~~. The bones ^{provide new data and} resemble those of C. monocerata, and, as is true of the holotype leg bones of C. dubia, ^{living} they fall within the size range of the modern species.

^{the extinct Godwit,}
The holotype ^{of} Limosa vanrosse Miller, 1925, (UCMP 26545) is a well preserved skeletal impression, lacking only the skull. It is approximately the size of the Recent Marbled Godwit, but with different ratios ^{in the} ~~of~~ lengths of the leg bones. This is the only species from the Sisquoc Formation that has not ^{yet} been recognized elsewhere, in at least one of the other late Miocene rock units in California.

A specimen of a Murre, genus Uria Brisson, 1760, in the Brodkorb collection (Univ. of Florida) is unrecorded. It consists of the skull and wing bone impressions on two slabs of diatomite. The genus Uria has been tentatively recorded (Howard, 1978) from the Monterey Formation in Orange County (LACM locality 6902). It is also recognized at UCMP locality 68147 (= LACM locality 4297) in San Diego County referred to the lower level of the San Mateo Formation, which is still under study. The specimens from the three localities are comparable in size.

(9) Mammals. - From the ^{Sisquoc Formation} ~~the~~

have come the holotypes

of three extinct species of marine mammals ^{that} we consider to be characteristic taxa of the late Miocene faunal assemblage: namely

the large sea lion-like walrus, Imagotaria downsi Mitchell, 1968,

the small, generalized ^{Otariid.} (fur seal), Pithanotaria starri Kellogg,

1925^b, and the sea cow, Dusisiren jordani (Kellogg, 1925a)

(a senior synonym of Hallianasa vanderhoofi Reinhart, 1959).

~~The type (and only recorded) specimen of the primitive humpback whale, Megaptera miocaena Kellogg, 1922, was also collected here.~~

Imagotaria downsi was originally described from a holotype
 (SBMNH 342) ^{which has} uncertain locality data, but ^{it is known to be} from diatomite in

the Sisquoc Formation at a quarry of the Great Lakes Carbon Company
 near Lompoc. A referred specimen (USNM 13487, Mitchell, 1968: 1865-
 1866, 1867-1868, fig. 15), however, does have accurate locality
 information, and is from the Sisquoc Formation in the present Johns

Manville quarries and from a site near where the holotypes of the primitive
^{Kellogg, 1922,}

humpback whale, Megaptera miocaena and Dusisiren jordani, and the referred specimens (Kellogg, 1922)
 of Pithanotaria starri were found.

The holotype of Pithanotaria starri (formerly Stanford Museum No. 11, now CAS 13665 Type Catalogue 7, ^{see} Firby, 1972) contains no actual bones but is the impression of the right side of most of an articulated skeleton, which can be used for comparisons with other specimens (Kellogg, 1925^b:73). The specimen represents a juvenile (as implied by Kellogg, 1925^b:74-75) and can be compared with bones from other ^{late Miocene formations} (Repenning and Ted ~~Ord~~, 1977) Good locality data exists for the holotype (Kellogg, 1925^b:74), which came from an area mapped as the Sisquoc Formation by Dibblee (1950: pl.1). The two referred specimens (UCMP 26784, 26785, ^{are} from another locality to the southeast (Kellogg, 1925^b:84, 87), in the present Johns-Manville Company quarry area, and also in rocks mapped as the Sisquoc Formation by Dibblee (1950).

A more recently collected skeletal impression of an adult fur seal (LACM 74069) was uncovered in [#] diatomite beds exposed in a commercial quarry of the Great Lakes Carbon Company, west of the Johns-Manville quarries, (LACM loc^{ity} 4156) which ^{were} ~~are~~ however, mapped as the Monterey Formation by Dibblee (1950: pl. 1). At LACM loc^{ity} 4156, the diatomite beds alternate with beds of cherty shales characteristic of the Monterey Formation. Obviously the geologic picture is not yet resolved and there may be inaccuracies in the mapping. We currently regard this new specimen (LACM 74069) as Pithanotaria starri and its enclosing ^{being in} rock as the Sisquoc Formation.

Dusisiren jordanii has been found ^{in several late Miocene rock units} elsewhere in California (Domning, 1978;
 and documented herein) but is recorded from ^{the Sisquoc Formation} by only the holotype, which is a
 skull and partial skeleton (formerly Stanford Museum No. 10, now
 USNM 11051). The specimen was collected
 in an area now occupied by the Johns-Manville quarries and near the collecting
 localities of the referred specimens of Pithanotaria starri, of the
 holotype of Megaptera miocaena, and ^{of} the referred specimen of Imagotaria
downsi. Thus, the close geographic and stratigraphic association of
 these four species of mammals in the Sisquoc Formation is a provable fact.

from the Sisquoc Formation

Although at least six large whales have been deposited in museum collections since the early years of collecting in the 1910's and 1920's, surprisingly only one small odontocete has ever been recorded (and to our knowledge discovered) from the diatomites at Lompoc. This is a slab of rock with several vertebrae (now catalogued UCMP 115863) labeled as No. CXXXVII by Jordan and Gilbert (1919a: pl. 28, fig. 1), and identified by them as Phocaena occidua (Leidy, 1868). They also identified as this ^{same} species, the impressions of some lamniform shark vertebrae from Lompoc (~~Bruce Welton, personal communication, 1976~~ ^{Now an author} illustrated by them (1919a: pl. 28, fig. 3) and numbered CXXXVIII (now catalogued UCMP 115862). Neither the referral of the ^{dolphin} vertebrae to the species ^{occidua}, nor ^{of the species} transfer to the genus Phocoena, have any justification (see Palmer, 1920:100), (originally Delphinus occiduus Leidy, 1868). Delphinus occiduus is now placed in the monotypic genus Lonchodelphis Allen, 1924, which is ^{still} known solely by the holotype rostral fragment from the Purisima ³³² formation (see Barnes, 1976) ^(UCMP 115863). The vertebrae [≡] should remain identified as odontoceti, incertae sedis until associated skulls and vertebrae are found. Likewise, the small odontocete vertebra [≡] e from San Pedro ^{also} assigned to P. occidua by Jordan and Gilbert (1919a: pl. 9, fig. 2) are in reality unidentifiable at present.

(9) The primitive humpback whale, Megaptera miocaena, was one of the first recorded fossil cetaceans from California.

The species

has not been reported by any additional specimens (Barnes, 1976:329) since the description by Kellogg (1922).
of the holotype, USNM 10300

Kellogg's (1922:2-3)

original description of the type locality

places it in the Sisquoc Formation

(Dibblee, 1950: pl. 1), not far from the source of the referred specimens of Pithanotaria starri, in the present quarries of the Johns-Manville Corporation.

Chronologic Position and Age

Jordan's age, cited in
early fish papers

a fossil mammal (Megaptera miocaena) from the Sisquoc
who visited the locality

diatomite

In his first article on Formation, Kellogg, (1922:3) called
the deposit "equivalent to the Temblor or lower Miocene". By 1925

(1925a:60; 1925b: 75, 84, 89), while still not applying a formational
name, he

However, At the time, cited the age as "Sarmatian, or
Upper Miocene"; This correlation with the European chronology may

have been unfounded, but is probably very close to
reality.

Summarizing Miller, 1925
on age & environment

41

In the more recent literature

Sisquoc

The formation is usually called late Miocene to early Pliocene in age (Woodring and Bramlett, 1950; Barron, 1975: fig. 4; Barron, 1976:

fig. 6), but Dibblee (1950) called it early Pliocene. Woodring and Bramlett (1950); Ingle and Barron, 1978

34) stated that the lower and middle parts of the formation represent the Bolivina obliqua zone.

based on diatoms

Barron's (1976) correlations of the Sisquoc Formation are internally consistent with our vertebrate fossil data relating to other and with Barron's more recent () interpretation that the Sisquoc is late Miocene rock units in California, Miocene in age. His earlier deduction (1976) that the formation is early Pliocene in age and therefore about

5 million years old

was

, we believe, incorrect. The marine vertebrate assemblage from the Sisquoc Formation diatomites indicates to us direct and indirect correlations with the Mohnian Stage and the post-Mohnian to pre-Repettian Stage (cf. Barron, 1976:122) time interval. The interval represented would correlate with the

Bolivina obliqua Zone of Kleinpell (1938) in the Modelo Formation (cf. Barron, 1976), with the Clarendonian/Land Mammal of Europe age, and with the Tortonian Stage /Sarmatian correlative/

(Berggren and Van Couvering, 1974: Fig. 11). The Sisquoc Formation, therefore, is of Late Miocene

age and spans from about 9 to 12 million years ago.

§ Barron (personal communication, 1976, has identified the diatoms in the matrix of *Pithanotaria starri* and of a juvenile skull of *Imagotaria downsii* (Mitchell, 1968: 1868-1869) and has found that both are assignable to North Pacific Diatom Zone XI which currently (Barron, personal communication, 1978) is believed to be ~~between~~ about ~~6.3 and~~ 8.0 m.y. old. This young an age appears to be inconsistent with other age indications of the late Miocene marine invertebrate fauna, but at present there is no explanation of the inconsistency.

(15)

Locality.—Celite company #5 Quarry, Lompoc, Santa Barbara Co. 2½ mi. SE of Lompoc, 600' N of NW corner of NE¼ S. 22 (i.e., in center of S-½ of irregular S. 15), T6N, R34W, Lompoc Hills Quadrangle (7.5', 1947).

GEOLOGY: Specimens collected within 300' of top of 1400'-thick diatomaceous earth deposit (Kellogg, 1925: 60). David (1943: 118) indicates that "sea cows" and "whales" occur in Layer G3 of the deposit, below the principal occurrences of fish, but does not specify the locality or give measurements of the section.

FORMATION: Sisquoc Formation.

SIRENIAN MATERIAL: USNM 11051 (originally Stanford University Museum no. 10): (old adult) Skull with right periotic and ossicles, lacking rostrum, basicranium, and zygomatic processes; vertebrae T5, T8-10; 6 rib fragments; left metacarpal V. Coll. E. K. Jordan, May 1924. Holotype of *Dusisiren jordani* (Kellogg, 1925).

ASSOCIATED FAUNA: No other fossils known to have been directly associated with the sirenian; however, other diatomite quarries in the immediate area have yielded a considerable fauna including Osteichthyes (see David, 1943); *Puffinus diatomicus* (holotype), *Sula willetti* (holotype), *Morus lompo-canus* (holotype), and other birds (Miller, 1925); *Imagotaria downsi* (holotype), *Pithanotaria starri* (holotype), and *Megaptera miocaena* (holotype). The diatom flora is summarized by Barron (1973) and in references therein cited.

AGE AND CORRELATION: According to Dibblee (1950: 43) the 1000' or so of diatomite deposits SE of Lompoc constitute the lower part of the Sisquoc Formation, which contains foraminifera of the *Bolivina obliqua* zone (Woodring and Bramlette, 1950: 100), considered lower Delmontian.

(Domning, 1978: 155)

Lompoc.

UCMP 24221, distal end of a right tibia described by Kellogg (1925 IV, p. 93-95) probably male, from UCMP locality 3545 in the same beds but about 5 miles west of the type locality of Imagotaria downsi. Male size. This matches, as well as can be expected, an abraded female tibia from Santa Cruz. Also matches male tibia from Empire Formation and, as noted by Kellogg, Odobenus. From locality, must be Imagotaria.

Repenning,

Type locality and age.--See Mitchell (1968, p. 1845). The locality is in the Dicalite quarry of the Great Lakes Carbon Company seven miles southeast of Lompoc, California. The diatomite in this quarry is the same unit as that in the Celite quarry of the Johns Manville Company three miles south of Lompoc (Dibblee, 1950) which has been considered a facies of both the Monterey Formation and the Sisquoc Formation. Because of a regional unconformable relationship on the underlying parts of the Monterey of Mohnian age, Dibblee considers the diatomite to belong to the Sisquoc. Wornardt (1967, p. 11) noted a marked change of the diatom flora in the upper part of the 1,000-foot-thick diatomite and suggested that the Monterey-Sisquoc formational boundary occurred in the upper part of the diatomite but did not attempt to defend this boundary on a cartographic basis.

Based upon Foraminifera in the underlying and overlying units, most authors (Bramlette, 1946, p. 212, and Woodring and Bramlette, 1950, p. 101) consider the diatomite in these quarries to be early Delmontian. By estimation, the age is here presumed to be about 11 to 12 million years and is from the latest third of the middle Miocene.

Repenning & Tedford, 1977 m.s.

Distribution and Nomenclature

The Santa Margarita ^{Sandstone} Formation is a widely distributed, well known rock unit ^{with outcrops in hills} formation in California, ^{Southern} bordering the San Joaquin Valley and in the central California Coast Ranges. It was named by Fairbanks (1904) for alternating sandstones and conglomerates containing some beds of diatomite in the area of Santa Margarita in San Luis Obispo County, California. ^{predominately} Typically, it is a coarse, clean to silty, quartzitic sandstone deposited in near shore environments.

that is considered to have been

Exposures in the Caliente Range extend ^{northward} along the northeast flank of the La Panza Range and are traceable into the Salinas Valley. In the Caliente Range the Formation is 1000 feet thick (Hill, Carlson, and Dibblee, 1958:2995).

In the Temblor Range, Sespe Valley, and near Coalinga, ^{of the Santa Margarita Formation} are sands, which have their origin from granitic masses to the north and south.

Some of the best anatomical information for the marine mammals and some good continental correlations are provided by fossils found in ^{outcrops and} sand quarries ^{near Santa Cruz} in the Santa Margarita Formation in and around Scotts Valley. Here, ^{coarse} sandstones and conglomerates unconformably overlie older marine units and an ^{the Santa Cruz} ancient granite and are themselves overlain by ^{200 feet of} mudstone (Clark, 1966).

Localities in the Santa Margarita [?]Formation near King City and at other places in the coast ranges have produced scattered vertebrate fossils, but these are not yet well studied.

Conglomerates and sandstones on the east side of southern San Joaquin Valley have been mapped as the Santa Margarita Formation (Hoots, Bear, and Kleinpell, 1954).

Age of the referred material from the Santa Cruz area.--All remains of Imagotaria downsi in the Santa Cruz area have been found in the upper 100 feet of the Santa Margarita Formation, which is as much as 430 feet thick in some parts of the area. Many remains have been found in a widespread conglomerate in the upper part of the Santa Margarita in the northern parts of its outcrop area. This bed does not appear to be present to the south at the locality where the two skulls were found. However, the formation at this locality (USGS M1035) is only about 80 feet thick and the bones of Imagotaria have been found throughout a 30-foot zone approximately 15 to 45 feet below the overlying Santa Cruz Mudstone of Clark. The Santa Margarita Formation here rests on granite and thins against this underlying granitic high to 5 feet 4,500 feet to the north and to 2 inches 6,500 feet to the north of the locality (J. C. Clark, oral commun., 1973). The implication of the stratigraphic relations in the vicinity of this locality is that the formation was deposited against an ancient granitic high and that the 30 feet of fossil-bearing deposits represent a thickened facies of the widespread conglomerate found in the thicker sections to the north of this local granitic mass.

?
previous
reference
to 2 skulls?

The Santa Margarita Formation is of late middle Miocene age in the chronology here used, correlative to the Margaritan Stage of Corey (1954). This is certainly true of most of the formation in the Santa Cruz area (Mitchell and Repenning, 1963, p. 9, 12-14). However, the upper part of the formation contains several mollusks and echinoids generally considered indicative of an early ^{and} late Miocene age, characteristic of beds correlative with the lower part of the Jacalitos Formation (see Table 1). Clark (1966, p. 126-131) found his most definitive invertebrate fauna downsection from the gravel bed bearing many of the remains of Imagotaria. The desmostylian remains reported from this formation (Mitchell and Repenning, 1963, p. 9, 14-15) have been found only well downsection in the basal 100 feet or less of the formation and in those areas where the formation approaches 300 to 400 feet in thickness.

? Cape
Late

USGS? UCMP?
In the Pacific Coast Aggregate Company quarry on the north side of Bean Creek, Scotts Valley (fig. _____, localities M1104 and V4004) the Santa Margarita Formation is nearly 400 feet thick and rests on the Miocene Monterey Formation. Remains of Imagotaria have been found in the conglomerate bed here, very close to the top of the formation (locality M1104). Two hundred and eighty-five feet lower in the formation the type specimen of the sirenian Halianassa vanderhoofi Reinhart was found at UCMP? locality V4004. A few feet below this locality the left M² of Hipparion sp. cf. H. forcei (USNM 23892) has been found. A short distance to the south, on the opposite side of Bean Creek (UCMP locality V5555), a number of horse teeth have been collected from the Santa Margarita Formation which compare best with Hipparion ^hmojavense. At this locality specimens are collected in slumped sand and are not assignable to a specific part of the formation; however, they must have been deposited at least 75 feet higher in the Santa Margarita Formation than the horse tooth from the north side of Bean Creek.

Horses of these types occur both below and above the Moraga Formation (informally known as the Grizzley Peak Basalt) in the Berkeley Hills, California. This unit has been dated at 10 m.y. (G. H. Curtis, personal commun., 1973). An intervening formation, the Santa Cruz Mudstone of Clark, separates the Santa Margarita Formation from a glauconite at the base of the Purisima Formation dated at 6.7 m.y. (J. D. Obradovich, written commun., 1964). Available information thus suggests that the specimens of Imagotaria downsi, and associated otariid remains questionably referred to Pithanotaria, are about 10 m.y. old, earliest early late ^{Cal?} Miocene, and are probably younger than this same fauna in the diatomite of the Sisquoc Formation south of Lompoc. The referred specimen (UCMP 34789) from Comanche Creek, Kern County, California, appears to be more nearly the age of the type specimen ^{from Lompoc} whereas the referred specimen (UCMP 24070-82) from Soledad Canyon, Los Angeles County, California, appears to be more nearly the age of the specimens from Santa Cruz.

Marine Vertebrate Fossils

Scotts Valley

037?

Copied
from birds
3/19/80

Fishes:

Associated with the mammalian fossils are bones of birds, sharks (including Isurus) and the saber-toothed salmon, Smilodonichthys.

The avian fossils are under study by G. Victor Morejohn of California State University, San Jose. He notes (Morejohn, in litt. to H. Howard, 1974) that his preliminary survey indicates close tie-ins with the species found in the Siquoc Formation at Lompoc and with those in the Monterey Formation at

Laguna Hills. One species in the latter category, Puffinus calhouni Howard, has been recorded (Domning, 1978:153) from UCM P locality V 71197 on Glen Canyon Road in Santa Cruz County.

revised
1980

PUENTE FORMATION

The Puente Formation of southern California is a marine clastic rock unit of late Miocene age (English, 1926). The formation outcrops in some of the low hills around the eastern side of the Los Angeles Basin and vertebrate fossils have been collected from the upper, diatomaceous part in the vicinity of the cities of Covina, Pomona, and Walnut. Usually the diatomaceous shale is exposed in road cuts and quarries, and some specimens in LACM might have come from the commercial diatomite quarries near Covina (Wright, Chesterman, and Norman, 1954:74).

In the stratigraphically lower parts of the Santa Margarita Formation at UCMP Locality V-5555 in Scotts Valley have been found isolated teeth of Desmostylus, Paleoparadoxia (see Mitchell and Repenning, 1963:9, 12-14), the sea lion Allodesmus (Repenning and Tedford, ^{press 1977} ~~in preparation~~), and toothed whales Liolithax (Barnes, ^{1976:330, 1978:10-11} ~~in preparation~~) and Squalodon errabundus Kellogg, 1931 (new generic allocation needed, ¹⁹⁷⁶ ~~fide Barnes~~). These animals are found elsewhere in California in ^{the} Barstovian-equivalent ^{Round Mountain Silt} ~~marine sediments~~ near Bakersfield in Kern County (Kellogg, 1931) and at Stanford in San Mateo County (see ~~Repenning, 196~~ ² and Barnes, 197²), and their occurrence near the base of the Santa Margarita Formation with teeth of Hipparion indicates ^{marine mammal} that these ^A taxa in question survived later than the end of the Barstovian.

Horse teeth from lower parts of the section ^{in Scotts Valley} identified as Hipparion cf. H. forcei and Hipparion cf. H. mohavense are indicative of late ^{Early} Clarendonian age. ^{One tooth of the small browsing horse Archaeohippus cf. mowmingsi from these deposits (unpublished, fide Repenning) appears to record a Barstovian relic.} These ^{Hipparion} species have also been found in the Berkeley Hills above and below basalt in the Moraga Formation dated at 10 million years and in the North Tejon Hills local fauna in the Chanac Formation in the Tejon Hills stratigraphically above Santa Margarita Formation (Savage, 1955). Mollusks and echinoids in the upper part of the Santa Margarita Formation indicate an early Pliocene age (in the west coast sense), and are characteristic of rocks correlative with the lower part of the Jacalitos Formation.

From the upper levels of this formation have been collected fossils of Imagotaria sp. (Barnes, 1971), more recently identified as I. downsi (Repenning and Tedford, 1977), Pithanotaria starri (Repenning and Tedford, 1977), and Dusisiren jordani Kellogg, 1925 (see Vanderhoof, 1941; Reinhart, 1959; Domning,). These three species are characteristic of the assemblage described from the Sisquoc Formation at Lompoc.

Additional mammal fossils from this formation include bones of a large baleen whale, near Balaenoptera, a smaller one allied to Herpetocetus, and still another, identified (Barnes, 1976:329) as Nannocetus eremus Kellogg, 1929, which was originally described from the Towsley Formation in the San Gabriel Mountains.

Locality.—UCMP loc. V4004, Bean Creek, Santa Cruz Co. Gravel pit on N bank of Bean Creek, SE¼ S. 14, T10S, R2W, Felton Quadrangle (7.5', 1955).

GEOLOGY: Loose gravelly sand, 40'–50' above Monterey Shale, about 240' below an *Astrodrapsis* bed.

FORMATION: Santa Margarita Formation.

SIRENIAN MATERIAL: UCMP 3794: (adult) Nearly complete skull with periotics, tympanics, ossicles, right M¹⁻³, left M³; fragments of mandibles with right M₁₋₃, root of left M₃; vertebrae C1–5, C7, T7–14; parts of at least 10 right and 10 left ribs; manubrium; parts of scapulae; complete left humerus and radius-ulna and parts of right elements; right scaphoid-lunar-centrale and unciform. Whereabouts of left carpals and metacarpal III mentioned by Reinhart (1959) unknown. Coll. C. Peters and D. Baker [1940?]. Holotype of *Halianassa vanderhoofi* Reinhart, 1959. UCMP 88921: (adult) Waveworn proximal end of left humerus. Coll. ? UCMP 108556: Left M₃. Coll. P. Morgan. UCMP 114047: Right M₂. Coll. L. Phillips, Oct. 11, 1974. All referred to *Dusisiren jordani*.

ASSOCIATED FAUNA: *Paleoparadoxia*, *Desmostylus*, *Hipparion*.

AGE AND CORRELATION: The name Santa Margarita is applied to the thick yellowish to white arkosic sandstone unit cropping out conspicuously N of Santa Cruz, on the basis of lithologic, stratigraphic, and faunal similarity to the type Santa Margarita Formation in the upper Salinas Valley. The unit at Santa Cruz is described and mapped in detail by Clark (1966). It contains a diverse vertebrate fauna

and some invertebrates. *Hipparion* teeth from near the base of the formation (UCMP locs. V4004, V5555) are tentatively of early Clarendonian age (D. E. Savage, pers. commun.). Clark considered the lower part of the formation (which lies with angular unconformity on deformed Luisian beds) Mohnian in age (based on indirect correlation by land mammals with the upper Mint Canyon Fm. of southern California), and the upper part (above the sirenian occurrences), containing *Astrodrapsis spatiosus*, late Deimontian. These age assignments, however, refer to the Santa Margarita section in Scotts Valley, where the unit approaches its maximum thickness of 430'. Many of the marine vertebrate localities lie to the S and E along Glen Canyon Road—at lower elevation, across a basement threshold, and in a partly separate and perhaps more seaward basin—where the formation is thinner, and it is not clear how these localities correlate with the Scotts Valley section. Clark stated that Mohnian foraminifera were taken from what he considered the lower part of the Santa Cruz Mudstone (which conformably overlies the Santa Margarita) in a well W of Ben Lomond Mt., indicating a W-to-E and S-to-N marine transgression during Mohnian-Delmontian time. This implies that the Santa Margarita-Santa Cruz Mudstone contact is somewhat lower stratigraphically on Glen Canyon Road than farther inland in Scotts Valley, and hence that the upper Santa Margarita may be younger in the latter area.

(Domning, 1978:150–151.

Locality.—UCMP loc. V5555, Bean Creek, Santa Cruz Co. Sand pit S of Bean Creek, on NW side of Sky Park Airport.

GEOLOGY: Loose coarse sand with pebble lenses and large-scale cross-bedding.

FORMATION: Santa Margarita Formation.

SIRENIAN MATERIAL: UCMP 45273: Right M₁. Coll. E. and G. Pavey, ca. 1952. UCMP 95945: Left M₂. Coll. S. Skewis, 1966. USNM 184032: Right M₂. Coll. M. Lavarias. All referred to *Dusisiren jordani*.

ASSOCIATED FAUNA: *Isurus hastalis*, *I. planus*, *Carcharodon megalodon*, *Carcharhinus*, *Odontaspis*, *Galeocerdo*, *Pimelometopodon* cf. *pulchrum*; *Allodesmus*, Otariidae, *Liolithax* sp. (det. L. G. Barnes); Mysticeti, *Paleoparadoxia*, *Desmostylus*, *Hipparion*, Camelidae.

AGE AND CORRELATION: See under UCMP loc. V4004.

fauna

(Domning, 1978:151.

Locality.—UCMP V71197, Glen Canyon Road, Santa Cruz Co.

GEOLOGY: About 55' of coarse sand below gradational contact with Santa Cruz Mudstone; lower part loose and white, upper part yellowish and silty, forming bluff. Sirenians from white sand, birds and pinnipeds from lower part of yellow sand.

FORMATION: Santa Margarita Formation.

SIRENIAN MATERIAL: UCMP 103609: (juvenile) Rib fragments. Coll. P. Marshall, Dec. 3, 1972. Referred to *Dusisiren jordani*.

ASSOCIATED FAUNA: *Isurus*, *Smilodonichthys*; *Puffinus calhouni* (det. G. V. Morejohn); *Imagotaria*, *Pithanotaria*, Cetacea.

AGE AND CORRELATION: See under UCMP loc. V4004.

← P. 153.

Liolithax sp.

Figures 11, 2k, 3

Referred specimen.—UCMP 95984, right periotic with incomplete anterior process, collected by Joe Minor, about 1969.

Locality.—UCMP V-5555, Bean Creek Locality 2, Camp Evers Junction, near Felton, Scotts Valley, Santa Cruz County, California.

Formation and age.—Santa Margarita Formation, late Miocene. The specimen was collected by screening techniques from a coarse conglomeratic sandstone bed, overlain by massive sands in the lower part of the Santa Margarita Formation. The associated vertebrate assemblage from the bed includes sharks, *Desmostylus*, *Paleoparadoxia* Reinhart 1959 (a desmostylian), *Metaxytherium*, *Allodesmus*, *Hipparion* and other terrestrial mammals. (See also Mitchell and Repenning 1963:12–13.) The age is equivalent to the Clarendonian mammal age, Mohnian or Delmontian foraminiferal stages (see previous discussion on p. 7), and may be approximately equivalent to the Sarmatian Stage of Europe (Weaver, et al. 1944; Evernden and Evernden 1970). The lower part of the Santa Margarita Formation at UCMP locality V-5555 may be roughly correlated with LACM locality 3172 in the Monterey Formation in Orange County, where a periotic referred to *Liolithax kernensis* was found. The correlations suggest an age of 10 to 13 million years (Berggren and Van Couvering 1974: figs. 11, 12), and the occurrence is roughly correlated with the St. Marys Formation on the Atlantic coast of North America.

(Barnes, 1978:10)

Just north of Santa Cruz, California there are found in the late Miocene Santa Margarita Formation *Metaxytherium*, *Desmostylus*, *Hipparion* Christol, 1832 (see Mitchell and Repenning, 1963), *Allodesmus*, *Pithanotaria*, *Imagotaria* (see Barnes 1971, Repenning and Tedford 1977), and *Liolithax* sp. (this paper, p. 10). This association of mammals with the exception of the horse, *Hipparion*, matches that from locality 3172. The presence of *Hipparion* indicates that the Santa Margarita Formation near Santa Cruz is at least as young as Clarendonian, and therefore younger than the Sharktooth Hill Bonebed. Mitchell and Repenning (1963:12) also correlated the Santa Margarita Formation with the Neroly Stage and the Mohnian or Delmontian foraminiferal stages. *Imagotaria*, *Pithanotaria*, and the sirenian *Metaxytherium* have been reported from Clarendonian correlative marine rocks in California (Savage and Barnes, 1972). It can therefore be concluded that *Liolithax kernensis*, as represented by the periotic LACM 30160, lived after Luisian (Barstovian equivalent) time in California into Clarendonian time.

Locality.—UCMP loc. V5125, Cammatti Ranch, San Luis Obispo Co. Near mouth of canyon about 1 mi. N of ranch-house; middle of northern half of section line between Sections 31 and 32, T28S, R16E, Pozo Quadrangle (15', 1952).

GEOLOGY: Bones apparently from thin dark red-brown sandstone bed in top of lower (nonmarine) third, or from base of overlying marine portion, of Santa Margarita sandstone.

FORMATION: Santa Margarita Formation.

SIRENIAN MATERIAL: UCMP 40972, 45015: Rib fragments. Coll. J. W. Durham, Oct. 1951; D. E. Savage, 1952.

ASSOCIATED FAUNA: Myliobatoidea, *Dasyatis*, *Squatina*, *Isurus*, *Galeocерdo*, Teleostei, Testudininae, Carnivora, Delphinoidea, Mysticeti, *Hipparion*, Camelidae, *Merycodus*.

AGE AND CORRELATION: These beds could probably be traced to the type area of the Santa Margarita, some 20 mi. to the west. The presence of *Hipparion* and *Merycodus* indicates a Clarendonian age (Durham and Savage, 1954; Savage, pers. commun.); the associated marine strata are of an age near the Mohnian-Delmontian boundary (Durham et al., 1954).

Domning, 1978:153.

Sespe Valley

From outcrops of the lower white sandstone member of the Santa Margarita Formation in Santa Barbara County was collected the holotype of the odontocete, Lophocetus repenningi Barnes, 1978.

Type locality.—USGS M1217, "Stanford Locality," Pine Mountain, Sespe Valley, Santa Barbara County, California; Wheeler Springs Quadrangle, USGS, 1943.

Formation and age.—Santa Margarita Formation, late Miocene. The specimen was collected from the lower white sandstone member of the Santa Margarita Formation (see Dickinson and Lowe 1966:table 1, for stratigraphic relationships and fossil assemblages). The Santa Margarita Formation is correlated with the "Margaritan" provisional mega-invertebrate stage (Addicott 1972), the Clarendonian mammal age, the Tortonian ($\equiv$ Sarmatian) Stage of Europe (Weaver, et al. 1944; Berggren and Van Couvering 1974:figs. 11, 12), and with the St. Marys Formation of the Atlantic coast of North America, and is therefore approximately 10 to 12 million years old.

Barnes, 1978: 12-13.

Locality.—UCMP loc. 3557, Comanche Point, Tejon Hills, Kern Co. Slightly less than 1 mi. up Comanche Creek from mouth of canyon, on slope on W side of canyon. Not precisely located, but probably between the 700' and 800' contours about 1200' ENE of summit of Hill 1039; Arvin Quadrangle (7.5', 1955, rev. 1968).

GEOLOGY: Section recorded by C. L. Camp, Sept. 1919:

Top of cliff		Green clay	20 feet
Coarse sediment	20 feet	Green sandstone (vertebrate horizon)	2 feet
White sandstone	20 feet	White sandstone	20 feet

FORMATION: Santa Margarita Formation.

SIRENIAN MATERIAL: UCMP 29707: Rib fragment. Coll. C. L. Camp, 1919. Referred to *Dusisiren* Species B.

ASSOCIATED FAUNA: Cf. *Testudo*, Cetacea; *Hipparion* cf. *forcei*, *Pliohippus leardi* (det. D. E. Savage); *Ustatochoerus* cf. *major* (det. B. Lander); *Merycodus* s.l.

AGE AND CORRELATION: The name Santa Margarita is applied to the partly marine sandstone-mudstone sequence in the Tejon Hills on the basis of lithologic, stratigraphic, and faunal similarity to the type Santa Margarita in the Salinas Valley. Other localities in the Tejon Hills yielded (from the lower and upper Santa Margarita) the type mammalian fauna of Savage's (1955) Cerrotejonian Stage, which he correlated with the early Clarendonian mammal "age"; and (from the upper Santa Margarita) a molluscan fauna (listed in the same paper) which is probably of Neroly age (J. W. Durham, pers. commun.). (The oreodont and horse species from loc. 3557 are typically late Clarendonian (Montediablan), but Savage (pers. commun.) thinks that at least some of the fossils from this site may have been picked up as float derived from the overlying Chanac Formation, known to contain a Montediablan fauna. Since the Chanac seems to be entirely continental in origin, the marine mammals presumably came from the Santa Margarita.) R. H. Tedford (pers. commun.) regards Savage's Comanche Point (lower Santa Margarita) and South Tejon Hills (upper Santa Margarita) local faunas as "early Mohnian at the youngest" and "late Mohnian at the oldest," respectively. The sirenian localities probably fall between these horizons, and may be regarded as Mohnian.

Locality.—UCMP loc. 3558, Comanche Point, Tejon Hills, Kern Co. W side of Comanche Creek; not precisely located, but apparently in the vicinity of UCMP loc. V3916 (see below).

GEOLOGY: Not recorded.

FORMATION: Presumably Santa Margarita Formation.

SIRENIAN MATERIAL: UCMP 23969: (adult) Caudal vertebra, several ribs. Coll. C. L. Camp, 1919. Referred to *Dusisiren* Species B.

ASSOCIATED FAUNA: None.

AGE AND CORRELATION: See under UCMP loc. 3557.

Locality.—UCMP loc. V3916, Comanche Point, Tejon Hills, Kern Co. About ½ mi. up Comanche Creek from mouth of canyon, in middle of slope on W side of canyon. Exact locality may be about 800' SE of summit of Hill 892, on a knoll between two branches of an arroyo leading SE into Comanche Creek; Arvin Quadrangle (7.5', 1955, rev. 1968).

GEOLOGY: Specimens found in topsoil and on surface below gray sandstone; i.e., at level of white sandstone underlying the gray beds which in turn underlie the buff-brown beds of the Chanac Formation. Locality probably ~100' below base of Chanac. The gray and white beds (Santa Margarita) consist of interdigitating marine and nonmarine sediments; the Chanac consists of terrestrial fanglomerates. The most detailed description of the geology of this area is by Hoots (1930).

FORMATION: Santa Margarita Formation.

SIRENIAN MATERIAL: UCMP 34546: (probably subadult) Fragments of left exoccipital, jugal, and humerus. Coll. A. K. White and J. Seale, Apr. 1939. Referred to *Dusisiren* Species B.

ASSOCIATED FAUNA: *Imagotaria*, Equidae, Camelidae.

AGE AND CORRELATION: See under UCMP loc. 3557.

Tejon Hills

or what
Imagotaria's

start of A right metatarsal IV (UCMP) of a seal? was collected...

UCMP 34789, proximal half of right metatarsal III, probably male, from UCMP locality V-3916, White-Seale Locality below the gray sandstone member of the Santa Margarita Formation about 1/2 mile up Comanche Creek from the mouth of the Canyon in middle of slope on west side of Canyon; ~~upsection from Comanche Point local fauna~~ Kern County, California. This locality ~~is~~ is upsection from the Comanche Point local fauna and is Cenotejanian or possibly Montedriablan, late middle Miocene and approximately 11 to 12 my old but possibly somewhat younger. Collected by K. A. Richey in 1939. The metatarsal is identical to that in the pes from the Towsey (Modello (sp. ?)) Formation described by Kellogg (1925 ⁸⁷⁻¹¹⁶ ~~31~~ ⁴³⁻⁴⁵), p. 43-45) and to specimens of this bone from *Imagotaria downsi* in the Santa Cruz area. I am referring it to *Imagotaria* sp. on the grounds that specific identification is questionable on such limited material although I am convinced that only one species lived off Californian shores during this time. Without knowing its age, however, I couldn't separate it from the different species Emory is collecting from the Empire Formation.

Chronologic Position and Age

In the Caliente Range the formation contains reefs of Ostrea titan and is late Miocene in age, Mohnian and/or Delmontian, ^{It} occurs above Luisian age strata, and below the Pliocene Morales Formation (Hill, Carlson, and Dibblee, 1958:2995).

At Comatta Ranch, southeast of Paso Robles in the coast range, Clarendonian terrestrial vertebrates, including Hipparion, were collected stratigraphically below a marine invertebrate fauna in the Santa Margarita Formation. The invertebrates are representative of the "Margarita" ⁿ stage and correspond approximately with the boundary between the Mohnian and Delmontian foraminiferal stages (Durham, Jahns, and Savage, 1954; Durham and Savage, 1954). Marine vertebrates from the site are in the University of California Museum of Paleontology, but it is not certain whether they originated from the sediments producing the terrestrial vertebrates or the marine invertebrates. Included are bones of cetotheriid whales and a dugongid sirenian. These are not more accurately identified, and more material from the site may prove very informative.

On the east side of the San Joaquin Valley, conglomerates and sandstones of the Santa Margarita Formation overlie Temblor-age rocks and are the near-shore equivalents of such deep water formations as the Reef Ridge, McLure, Antelope, and Upper Maricopa in the middle of the valley (Hoots, Bear, and Kleinpell, 1954).

Clark (1966) placed the Miocene-Pliocene boundary, the Mohnian-Delmontian boundary, and the Clarendonian mammal age within an approximately 320 foot thick section of sediment identified as the Santa Margarita Formation in the Scotts Valley area near Santa Cruz.

In the Tejon Hills in southeastern San Joaquin Valley, strata referred to the Santa Margarita Formation are overlain by the continental Chanac Formation (Durham and Savage, 1954; Durham, Jahns and Savage, 1954). The Chanac Formation has yielded late Clarendonian mammals, which constituted the North Tejon Hills local fauna described by Savage (1955), and which he correlated with the Montediablan Stage represented by the Black Hawk Ranch local fauna in the east San Francisco Bay Area. The North Tejon Hills local fauna includes Hipparion forcei, Hipparion cf. mohavense, and Pliohippus leardi.

The underlying Santa Margarita Formation has produced the South Tejon Hills and Comanche Point local faunas which constituted the early Clarendonian Cerrotejonian Stage. These local faunas contained Hipparion sp., Nannippus tehonensis and Plihippus tejonensis (Savage, 1955:15). We introduce here as new records for the Cerrotejonian Stage, Imagotaria sp. (Repenning and Tedford, 1977), and Metaxytherium jordani (Domning, in preparation). Imagotaria sp. is represented by a right third metatarsal (UCMP 34789) which is identical to bones of Imagotaria from the Towsley Formation and from the Santa Margarita Formation near Santa Cruz (Repenning and Tedford, 1977). From CIT Locality 104, which is stated to be in the Chanac Formation, there has been collected a large pinniped astragalus (CIT 1166) which compares favorably with that of an adult Imagotaria. M. jordani is represented by skull fragments and ribs (UCMP 3557, 3558).

listed as Chanac chackit

THE TOWSLEY FORMATION

Three species of mammals have been found in the ^{west end of the} San Gabriel Mountains in the Humphreys Syncline about six miles northeast of Newhall in Los Angeles County. These are: the holotype cranium of a primitive baleen whale, Nannocetus eremus Kellogg, 1929; foot bones identified by Kellogg (1925) as the sea lion Pontolis cf. P. magnus (True); and the recently reported ulna and mandible of the sea cow Dusisiren jordani (Domning, 1978: 21, 155-156).

Repenning and Tedford (1977: 24) have determined that the sea lion foot bones described by Kellogg [actually] ^{downsi} are those of Imagotaria. These mammal occurrences are important because all three taxa are also known from the Santa Margarita Formation in ^{and Imagotaria and jordani are known from the Sissuoc Formation.} Scotts Valley. The sites producing these fossils are in a hilly area directly south of the community of Humphreys. Here the basal, nodular levels of a marine sandstone unit reputedly of late Miocene to early Pliocene age were referred by Winterer and Durham (1962) to the Towsley Formation. These same rocks were called Fernando Formation by Kellogg in 1925, Pico Formation by him in 1929, and Repetto Formation by Oakeshott (1958). Winterer and Durham ⁽¹⁹⁶²⁾ avoided placing a precise age on these deposits except to state that elsewhere the ^{Towsley Formation} conformably overlies the Modelo Formation. They correlated the Modelo with the Mohnian foraminiferal Stage, and with the Cierbo and Neroly molluscan stages. We feel that these ^{mammal} fossils from the Humphreys Syncline, being from the base of the Towsley Formation, are ^{the same or} only slightly younger than the age assigned to the Modelo Formation and ^{and post-Mohnian age} are themselves of ^a late Miocene ^(Clarendonian equivalent age), and therefore ^(sensa Addicott, 1972) represent the "Margaritan" stage, and possibly the Delmontian foraminiferal Stage.

Paleogeographic and paleoecologic evidence presented by Winterer and Durham⁽¹⁹⁶²⁾ suggests these mammal remains were deposited in water of moderate to shallow depths northwest of an exposed highland of older basement rocks at the east end of the Neogene Ventura Embayment. This description suggests a physical environment^{and paleogeography} similar to that envisioned at Scotts Valley at the time of deposition of the Santa Margarita Formation. The similarity in lithology and inferred paleogeography and sedimentary environment between the Towsley Formation at Humphreys and the Santa Margarita Formation at Scotts Valley may suggest that the conditions were favorable for the three mammals found at both sites: Imagotaria, Metaxytherium jordani, and Nannocetus eremus.

Undifferentiated Repetto Fm. in Humphreys Syncline

has calcareous concretionary sandstone at its base. Winterer and Durham (1962:288) assign these outcrops to the Towsley Formation.

If you ignore the section line on Oakshot's (1958) map and follow the very inaccurate contour lines, the mapped westward extending point northwest of hill 2004 on Mint Canyon 1:24000 Quad, USGS, 1960 (mapped as 2006 on old Fernando's Quad) and as 2006 on Oakshot's (1958) map, where it is marked too far to the east. The mapped rock units on Oakshot (1958) here are undifferentiated Repetto Formation of lower Pliocene age overlying Mint Canyon Formations. Oakshot however, shows Modelo Fm. between the Repetto and the Mint Canyon ~~at the~~

~~unit~~ Southeast of this point, just in Mint Canyon, ^{undoubtedly} Modelo Fm., Repetto Fm. is the ~~chronologic~~ stratigraphic sequence in the area.

Yes the exposure ~~of~~ ~~map~~ ^{map} Sect. 20 of T. 4 N. 12 E. R. 15 W. ^{mapped} as undifferentiated Repetto by Oakshot is mapped by Winters and Krumm as Towsley, predominantly siltstone and sandstone with

Map 1 area W / Lycopodium reticulatum

The Modelo of Oakshot is in the area of / Malheur and Nevada - Colorado -

Locality.—LACM (CIT) loc. 441, near Humphreys, Los Angeles Co. Originally recorded as on Sylmar Quadrangle (1:24,000, 1935), 34° 24' 02" N±, 118° 26' 55" W±, 4600' due SE of Southern Pacific Railroad underpass under Sierra Highway, on S side of hill; but hill in question is actually on Humphreys Quadrangle. On Mint Canyon Quadrangle (7.5', 1960) it is near center of W side of NW¼ SW¼ S. 27, T4N, R15W.

GEOLOGY: The probable locality is the larger, higher, and more eastern of two exposures on the S side of the hill. It exposes about 150' of section, the lower part of which is as follows:

Thick yellowish-brown sandstone with scattered pebbles		Cobble conglomerate with shell fragments.....	4 feet
Pebble conglomerate	1 foot	(Unconformity)	
Brown sandstone.....	1 foot	Greenish mudstone.....	½ foot
Fine pebble conglomerate	1 foot	Massive greenish-gray sandy siltstone with pebbles	
Brown sandstone with pebbles (sirenian horizon?)	1 foot		

The sirenian bones, which are dark brown with coarse pebbly dark brown sandstone matrix, were collected about 5' above the unconformable contact of the "Modelo and Mint Canyon Formations." The section above agrees well with Oakeshott's (1958) descriptions of the upper Mint Canyon and basal Modelo Formations in this area, though the lithology of the upper unit could just as well pertain to the Towsley Formation of Winterer and Durham (1962).

FORMATION: Probably Towsley Formation of Winterer and Durham (1962) (= Repetto of Oakeshott, 1958). Alternatively, the locality may lie in the Modelo Formation of Oakeshott (1958) (= Castaic of Winterer and Durham, 1954), if, as the latter two papers indicate, this unit is present at the site.

SIRENIAN MATERIAL: LACM (CIT) 6904-5: (adult) Part of right radius-ulna; mandibular symphysis. Coll. ?. Indistinguishable from and provisionally referred to *Dusisiren jordanii*.

ASSOCIATED FAUNA: No other fossils known to have been collected with the sirenian bones. Loc. 441 is, however, only ¼ mi. SW of Oakeshott's (1958: 74) "Locality No. Modelo 10," which yielded a molluscan fauna. I collected a small number of molluscs from the massive yellowish-brown pebbly sandstone 5'-10' above the presumed sirenian horizon; they included *Lyropecten estrellanus catalinae* (det. J. T. Smith). From the same area and probably equivalent beds have come *Imagotaria* (UCMP locs. 3584-5) and the holotype of *Nannocetus eremus* (UCMP loc. V2202).

AGE AND CORRELATION: The underlying, nonmarine upper Mint Canyon Fm. is Clarendonian (but not latest Clarendonian) in age. The marine Modelo in this area has yielded many Cierbo-Neroly molluscs and Mohnian foraminifera (Oakeshott, 1958, and references therein cited). The Towsley Fm. at Elsmere Canyon, 4 mi. SW of loc. 441, is Jacalitos in age (Kern, 1973). Hence the sirenian locality is probably between Mohnian and Jacalitos (early Repettian) in age.

(Domning, 1978: 155-156.)

(Towsley Fm.)

054



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Branch of Paleontology & Stratigraphy
345 Middlefield Road
Menlo Park, California 94025

September 26, 1973

Dr. Lawrence G. Barnes
Department of Paleontology
University of California
Berkeley, California 94720

Dear Larry:

Regarding Modelo-Towsley Formations - Towsley straddles the "Mio-Pliocene" boundary -- Santa Margarita of the Santa Cruz area. Modelo underlies Towsley here and there.

Calif. Div. Mines Bull. 172, 1958, by Gordon Oakeshott, maps the locality of Kellogg's Pontolis cf. magnus pes from "Sec. 27, T. 4 N., R. 15 W., near the section line directly west of 2,006 ft elevation hill." If "Section line" means "section" and not "1/4 section," this locality is in the Mint Canyon Formation and over 1/2 a mile west of the hill. Inasmuch as the locality description mentions collecting marine mollusks [of Santa Margarita nature], this doesn't sound like Mint Canyon.

If "Section line" means "1/4 section" line, then the locality is about 0.05 mile west of hill 2,006, which fits my concept of "directly west" better, and is in what Oakeshott calls Repetto Formation. The lith. description of the Repetto matches that of the locality. Note that it is the only marine unit on the mountain and that there is no Modelo present.

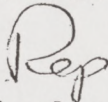
1962
Winterer and Durham, USGS Prof. Paper 334-H, 1962, name Oakeshott's "Repetto" the Towsley Formation. Their map doesn't extend as far east as the locality, but does overlap Oakeshott's western edge at a hill west of the locality where Oakeshott has another outcrop of Repetto which W. and D. remap calling it Towsley. From this outcrop W. and D. (p. 306) collected an invertebrate fauna (F18 and 19) and also they list the invertebrates found by Kew (1924) who called it a member of the Modelo Fm; a mile to the south in the Towsley and also they list the invertebrates collected by Gale (Grant and Gale, 1931) in the same outcrops where the pes was found. These are early Pliocene (old West Coast convention) and could be no older than the younger, Imagotaria-bearing part of the Santa Margarita at Santa Cruz.

J. Philip Kern, U.C., P.G.S., vol. 96, 1973, p. 12 et seq., discusses the age of the Towsley on the other side of the San Gabriel fault where older parts are present.

I believe I said that I am calling the pes Imagotaria sp. While I think it probably is I. downsi, there is a fair possibility that the locality is young enough to contain the Empire species that hasn't been prepared yet (Clayton's 3-foot skull) and so far I am not sure they can be separated on foot bones. In fact, enigmatic Pontolis itself may have similar foot bones and Kellogg may be right in what he called the foot. But, so far, it is still not possible to say what Pontolis is.

Anyhow, it is younger than what people now call Modelo and clearly out of what they now call Towsley. What was your 1968 reference?

Best regards,



Charles A. Repenning

(Towsley Fm.)

056

October 24, 1973

Dr. Charles A. Repanning
U.S. Department of the Interior
Geological Survey
Branch of Paleontology and Stratigraphy
345 Middlefield Road
Menlo Park, California 94025

Dear Rep:

Regarding localities at Humphreys Station: We have ^{five} four known specimens of mammals from these deposits.

- 1.) UCMP ³⁵⁸⁴~~24083~~, isolated metapodial, published by Kellogg, 1925 as Pontolis cf. magnus Sec. 27, T.4N., R.15W., near sec. line directly west of hill 2006.
- 2.) UCMP ³⁵⁸⁵~~24070~~, ²⁴⁰⁸² pes published by Kellogg, 1925 as Pontolis cf. magnus SW 1/4, NE-1/4 Sec. 27, T.4N., R.15W.
- 3.) UCMP ²⁶⁵⁰²~~24070~~, type skull of Nannocetus eremus Kellogg, 1929, on section lines 27-28, T.4N., R.15W. near Humphreys.
- 4.) LACM ^{(CIT)441}~~6904~~, ulna of Metaxytherium "34°24'2"N., 118°26'55"W. 4600' due s.e. of the S.P.R. underpass under the Sierra Highway." In marine beds about 5 ft. above unconformable contact with Mint Canyon Formation.
- 5.) LACM ^{(CIT)441}~~6905~~, mandibular symphysis of Metaxytherium.

You listed locality for 1.) above as the locality of 2.) in your letter to me dated September 26, 1973. Read Kellogg 1925, p. 98 very carefully. I have checked out Oakshott, 1958 and Winterer and Durham, 1962, and agree all are in Towsley Formation as defined and stated by the latter on pp. 288-289. They all probably come from the basal Towsley Fm. which in the Humphrey Syncline is gravelly and has calcareous sandstone concretions. All three taxa are found in the upper levels of Santa Margarita Formation at Scotts Valley.

(Towsley Fm.)

Dr. Charles A. Repenning

-2-

October 24, 1973

057

I had originally thought we should consider these fossils as having come from the Modelo Formation because it lies stratigraphically and chronologically between the Mint Canyon Fm. and the Towsley Fm. and is physically such just southeast of these localities. But Winterer and Durham state that westward the Towsley laps onto the Mint Canyon Fm. unconformably.

I believe Kellogg (1925:98) meant what he said about section lines but was not being precise enough when he said, in relation to locality UCMP 3584, "near the section line." He is equally vague for the description of locality UCMP 3585 (the articulated foot) which is northeast of UCMP 3584. Using Mint Canyon Quadrangle (1:24000, USGS, 1960) we don't have to assume UCMP 3585 is 1/2 mile west of Hill 2006, but only due west and near the section line. Hill 2006 on Oakshott's (1958) map and the old Fernando Quadrangle is Hill 2004 on the 1960 edition. It is mislocated too far east toward the center of section 27 by Oakshott's map. Follow the crude contours on Oakshott's map and the area of UCMP 3585 is believably Repetto Fm. (equals Towsley Fm.).

Since the underlying Modelo has Mohnian foraminifera and the mammals are from the basal Towsley, we could correlate them with late Mohnian -- Delmontian which correlates with Sisquoc, Santa Margarita, and Laguna Hills sites.

I am saying this in our Dallas report. Can we include some of your slides of Imagotaria skulls, jaws, or limb bones for the talk? Do you have a slide of the Pithanotaria starri skeleton?

Sincerely,

Lawrence G. Barnes
Associate Curator
Vertebrate Paleontology

LGB:mm
cc: Daryl P. Domning

October 29 -

Dear Larry -

Right - I noted right after I mailed ^{my letter to you} ~~your~~ letter that I was reading the locality description for the isolated MTI rather than the whole pss

Soledad Canyon

UCMP 24070-82, a right pes from the Towsley Formation (I haven't run this down to see if it should be Modello ~~F~~ - do what you like) of very Early late Miocene age south of Humphreys, Soledad Canyon, Los Angeles County (Not San Diego County), California. Kellogg (1925 II, p. 97-116) described this specimen under the name of Psittacus cf. magnus. I am referring it to Imagotaria sp. The portions of astragalus and calcaneum, the cuboid, the navicular, ^{and the} metatarsal III _{etc.} can be closely matched by material from Santa Cruz. As I recall you have a metatarsal I which matches from El Toro - is this correct?

Repenning

MODELO FORMATION

On the north flank of the Santa Monica Mountains bordering the ^{l.c.} south margin of the San Fernando Valley in central Los Angeles County are exposures ^{and diatomaceous late Miocene} of fine grained marine shales. These rocks in the Santa Monica Mountains which were called the Modelo Formation by Hoots (1931), are not continuous with those in the type section of the formation to the northwest in the Santa Clara Valley district. The Modelo Formation in its type area contains rocks of middle Miocene and late Miocene ("Margaritan") age, but all of the Modelo in the Santa Monica Mountains is younger than the underlying middle Miocene Topanga Formation of "Temblor" age (see Hoots, 1931:101-102). The ^{Formation} Modelo in the Santa Monica Mountains is wholly of marine origin, and the marine vertebrates reported herein (from the rock unit) are all from the upper member which is mostly ^{comprised of} soft white diatomaceous shale with a maximum thickness of 2,300 feet. The shale contains thin beds of volcanic ash, and is rich in fossil diatoms, radiolarians, foraminifera, sponge spicules, and silicoflagellates. Some assemblages of foraminifera in the upper member of the Modelo from the north side of the Santa Monica Mountains are equivalent in age to those in the upper part of the formation in Modelo Canyon where overlying shales have been considered of "Santa Margarita age" (Hoots, 1931).

A dolphin skeleton has been found in white diatomaceous shales of the upper member of the Modelo at Studio City (LACM Locality 1230) on the north side of the Santa Monica Mountains. This dolphin is a generalized delphinoid of a new species apparently ^{the} the genus Pithanodelphis Abel, 1905. The genus is known previously only from late Miocene rocks in the Antwerp district of Belgium, and we have also found the species in the Monterey Formation at Laguna Hills (see subsequent text).

where
is it?
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or south?

REVISED
March 1980
Birds

copied 3/19/80
as 061 and 062 (010618) Models

061 A +
B
as revised

Bird specimens have been reported in the Modelo Formation at four localities on the San Fernando Valley side of the Santa Monica Mountains and at one site in El Sereno closer to Los Angeles. A single humerus was found in El Sereno, and was assigned to Palaeosula stocktoni (Miller), the type of which is from the Valmonte Diatomite of the Monterey Formation near Lomita. Originally described as Sula stocktoni Miller (1935:75), the assignment to a new genus, Palaeosula (Howard, 1958:12) was based upon details of the El Sereno bone, which reveals characters only hinted at in the associated wing bones of the holotype.

The specimens from the San Fernando Valley side of the Santa Monica Mountains occur as incomplete skeletal impressions of associated skeletal parts. Unlike the bird imprints from Lompoc, however, portions of fragmented bone are present. Three species of ^{are} ~~solid~~ [^] ~~solids~~ recognized. One, (LACM 5001) from LACM locality 1752 near Encino, is ~~previously~~ unrecorded and requires further study. It represents a large gannet-like species, possibly undescribed. A second, from LACM locality 1229 in Studio City, was described as Sula pohli Howard (1958:4). The third ^{solid} [^] specimen, from LACM locality 1267 in Sherman Oaks, is assigned (Howard, 1962) to the Lompoc species, Sula willetti.

^{are} ~~Puffinus diatomicus~~ (type from Lompoc) and ~~also~~
Also recorded from LACM locality 1267 is Osteodontornis orri ~~(see~~
^{The latter is}
Howard, 1957), represented here by "toothed" jaw fragments and an atlas vertebra (Howard and White, 1962). Osteodontornis orri was originally described (Howard 1957) from the Monterey Formation in Tepusquet Canyon, and is also found at sites in the Monterey Formation in Orange County (see below).

A fourth San Fernando Valley site, near Calabasas, yielded a single specimen of the cormorant, Phalacrocorax femoralis Miller (1929), a species that is unknown elsewhere.
Miller 1929

Sula ^{pohli} LACM loc. 1229, Van Nuy's Quad.

Pithanodelphis n.sp. LACM loc. 1230. "

Puffinus diatomicus, Osteodontornis orri, Sula willetti
LACM loc. 1267, Van Nuy's Quad.

Xyne grex

Chauliodus

eximius

} = Lompoc.

The above-listed
birds ^{are} discussed
on previous page 061

Modelo in San Fernando Valley has Molinian forams.

See Wintora & Durham, 1962; circa 288.

MONTEREY FORMATION

Geologic maps show the Monterey Formation to have a wide distribution in California. ^{ll} The most significant localities in the formation ^{ll} for this study, are found in the Laguna Hills in Orange County, in Tepusquet Canyon in Santa Barbara County, and in the Palos Verdes Hills in Los Angeles County.

Tepusquet Canyon

^{ll} About 50 miles northeast of the Lompoc ^{diatomite} quarries in the Sisquoc Formation, ^{ll} in Santa Barbara County, is the quarry of G. Antolini and Sons. Here the hard, sandy shales are mined for flagstone. Although geologists agree that the quarry is in the Monterey Formation, the rocks lack identifiable foraminifera and opinions differ as to the precise age.

Vertebrate fossils from this locality include whales, small odontocetes, otariids, birds, and fish, ^{except for the birds} but most have never been placed in scientific institutions and are therefore unstudied.

Revised 065
ASG:ATB
1980

Three species of birds are known from the Tepusquet Canyon Monterey Formation.

The holotypes of two genera and species of birds come from the Tepusquet Canyon Monterey Formation. These are Osteodontornis orri Howard, 1957 (SBMNH no. 309) and Palaeoscinis turdirostris Howard, 1957 (LACM no. 2604). Both specimens consist of nearly complete skeletons (with some feather impressions) exposed on obverse and reverse slabs.

③ Palaeoscinis is a passeriform bird of the suborder Oscines, but later (Brodkorb, 1978) placed with the Solitaires in the family Muscicapidae. It is unknown elsewhere. originally assigned to a distinct family Palaeoscinidae.

② Osteodontornis, a marine bird of gigantic size, is characterized by bony, tooth-like projections on the jaws. It is assigned to an extinct suborder, Odontopterygia, within the Order Pelecaniformes, but shows characters suggestive of the albatrosses as well as those of the pelicaniform order. Fragmentary remains of Osteodontornis have been found at LACM localities 1945, 6902 and 7136 in the Monterey Formation of Orange County (Howard, 1968 and 1978) and at LACM locality 1267 in the Modelo Formation on the north slope of the Santa Monica mountains (Howard and White, 1962). Those from locality 7136 and locality 1267 are sufficiently well preserved to justify assignment to O. orri. Extremely large wing bones, undoubtedly of the genus Osteodontornis also occur in the Barstovian correlative Sharktooth Hill bonebed, in the Round Mountain Silt, but the species represented is undetermined and the specimens are still under study.

① A third avian specimen (SBMNH no. 310) from the Tepusquet Canyon locality is a shearwater, referred to Puffinus sp. (Howard, 1957b). It consists of a single slab of matrix with only the wing bones represented. There are no qualitative characters evident on which to base a specific identification. It is notably larger than the Sisquoc Formation Puffinus diatomicus, and the Monterey Formation P. calhouni, Howard, 1978, but possibly agrees in size with P. barnesi (Monterey Formation). (LACM loc. 1945) and (LACM loc. 6906)

Southeast Los Angeles Basin
~~CAPISTRANO SYNCLINE~~

A predominantly shale rock unit deposited in a large synclinal basin in the Laguna Hills region of southern Orange County has been called the Monterey Formation (Woodford, 1925; Vedder, Yerkes, and Schoellhamer, 1957; Morton, Miller, and Fife, 1973; Morton, Edgington, and Fife, 1974). The base of the formation contains limestone beds (Morton, Edgington, and Fife, 1974:48, 49, pl. 1) directly overlain by shale containing Luisian foraminifera (G. Hornaday, personal communication to Barnes), and sandstone beds containing as yet unpublished vertebrates.

The more southerly exposures of the Monterey Formation in Laguna Hills produce distinctly younger, late Miocene marine vertebrate assemblages. These are apparently from stratigraphically higher parts of the Monterey Formation and are in some places close to the contact with the superjacent Capistrano Formation. These late Miocene assemblages can be broken down into an early phase and a late phase, notably by the presence of some relict middle Miocene taxa in the former. Imagotaria downsi, Pithanotaria, and Metaxytherium jordani appear in both the early and late phase, but Desmostylus, Liolithax kernensis and Allodesmus are found only in the early phase.

The
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lc ?

Laguna Hills

Construction projects in the Laguna Hills southwest of El Toro in Orange County have exposed at least four sites that have produced the characteristic association of Imagotaria downsi, Pithanotaria, ~~starr~~ ^{starr} and Metaxytherium jordan. ^{LACM localities?}

Published geologic maps indicate that the localities are in the Monterey Formation. ~~This may or may not be correct;~~ both Mohnian and Luisian foraminifera have been identified from nearby rock sequences, but there are no foraminifera ^{reported} associated with the vertebrate remains. ~~The fact is that~~ the vertebrate ^{assemblages} ~~samples~~ found in Laguna Hills contain ^{many} taxa identical with those found in the Sisquoc and Santa Margarita ^{formations}.

Use
report

The early phase of the late Miocene is best characterized by the faunule from LACM locality 1945 (see Howard, 1968) and others which are closely associated geographically and stratigraphically. These were exposed and available for collecting during a short period of time in late 1964 and early 1965, during construction of a housing development.

Shelton P. Applegate has provided the following statement regarding the elasmobranchs from the locality:

"The Los Angeles County Museum's locality number 1945, now a lawn in Leisure World, represented the most productive concentration of sharks' teeth that has been found in western North America. The sharks from this locality and nearby Laguna Hills localities show a persistence of primitive genera--Squatina, Squalus, Heterodontus, and Dasybatus. Surprisingly there is also in this fauna an undescribed genus of echinorhinid. Myliobatis is represented by teeth that are identical to the living Myliobatis californicus. There is, however, another kind of very deep-bodied tooth plate evidently representing an undescribed species of Myliobatis. The Carcharhinidae, particularly the genus Carcharhinus, dominates the fauna, as is evidenced by the hundreds of teeth in these beds. The teeth are thought to represent extinct, as well as living, species of Carcharhinus, with a body size range of less than seven feet judging from tooth size. The blue shark, Prionace glauca, first occurs at LACM 1945. The genus Hemipristis is present though rare, represented by quite large teeth, often over an inch in width at the base. Such large teeth are usually seen in the Pliocene but are not present in Barstovian-equivalent rocks. The tiger sharks are represented by one species, Galeocerdo aduncus.

Though common in the Middle and Late Miocene it seemed to disappear at the close of this period. The great white sharks are represented by three species, Carcharodon megalodon, Carcharodon sulcidens, and Carcharodon carcharias. As with the blue shark, these are the oldest beds from which the modern species of great white shark is known. The mako sharks, Isurus, are amazingly numerous. Not only do we find the two living species, Isurus oxyrinchus and Isurus belyaevi, but also the large-toothed isurids which presumably devoured marine mammals are presented by four species: Isurus benedeni, Isurus planus, Isurus hastalis, and a pegged-toothed species as yet undescribed. All of these isurids differ from the early Miocene species.

"The total shark fauna appears to be much more tropical than that off the coast of California today. Subsequent history suggests that there was both a migration of the tropical Miocene species to the south and a number of extinctions, resulting in the reduced modern California selachian fauna."

*Coiled down to top
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The bird fossils from LACM Loc. 1945 were recorded by Howard (1968). All are fragmented bones with no association of elements. It is difficult, therefore, to make positive comparisons with the skeletal imprints from Lompoc upon which the Sisquoc Formation bird identifications are based. Because of this, none of the Lompoc bird species has been definitely recognized at LACM Loc. 1945. There are, however, ^{three} four possible instances of agreement. ^{two} Three are sulids, one an auklet.

Of the ~~three sulids~~, one ^{sulid} represented by a distal end of tibiotarsus (LACM 17570), is tentatively assigned to Morus lompocanus. The assignment is based on size plus the fact that the specimen does not resemble the similar sized tibiotarsus revealed in the holotype of Miosula media.

Two, ^{small} much smaller, sulid wing bones (LACM 17556 and 17555) are suggestive of Sula willetti in size, but no qualitative details can be compared. They can, however, be compared with descriptions and illustrations of the same elements of Microsula avita Wetmore, 1938 from the Calvert Formation (Middle Miocene) of Maryland, and are sufficiently similar to be indicative of generic, though not specific identity. The possibility that Sula willetti may also belong in the genus Microsula cannot be ruled out. As originally described, the genus was considered only a subgenus of Sula, characterized by reduced pneumaticity of the bones. It is impossible to judge the pneumaticity of the bones represented by the Lompoc imprints.

The proportions of large coracoid and tarsometatarsus and small radius and carpometacarpus noted in LACM specimens 17569, 17565, 17568 and 17566, which exhibit a distinctive type of preservation, suggested possible assignment to Miosula (Howard, op. cit.:12-13). Miller (1925:115) described the genotype, Miosula media, as having these proportions. ^{However} Now that good latex reverse casts (molds) of both obverse and reverse slabs of the holotype of M. media are at hand for comparison, this assignment is no longer tenable, at least for the coracoid, radius and carpometacarpus. Portions of these elements now brought into relief show distinctive qualitative characters that are not duplicated in the Laguna Hills specimens. Assignment of the tarsometatarsus is still questionable; certain characters of the proximal end seem to agree, but neither specimen is completely revealed in this area.

The fourth possible agreement among the birds from Lompoc and LACM Loc. 1945 Laguna Hills, is the auklet, Cerorhinca^{dubia}. Two wing bones assignable to this genus were found at LACM Loc. 1945. The holotype imprint from the Sisquoc Formation includes only the leg bones. The referred wing bones from LACM Loc. 4156 at Lompoc are slightly larger than those from LACM Loc. 1945, but both are within the size range possible for a single species (as validated by the Recent species C. monocerata). OK

Although shearwater bones are abundant at LACM Loc. 1945, none can be ascribed to Puffinus diatomicus, characteristic of the Sisquoc Formation at Lompoc. Several of the imprints of that species from Lompoc show a notably higher ectepicondylar process of the humerus than in any of the humeri from LACM Loc. 1945. The shearwaters here recorded are Puffinus calhouni Howard, 1968 (holotype LACM 17508), Puffinus sp. (larger than P. calhouni) ^{ateubatus agreement to} and P. priscus Miller, 1961, a species described from the Middle Miocene Sharktooth Hill Bonebed. Also suggestive of the Sharktooth Hill avifauna are two fragmentary goose leg bones assigned (Howard, 1968) to Presbychen abavus Wetmore, 1930, and a large pedal phalanx of an albatross that possibly represents Diomedea californica Miller, 1962. The latter identification is strengthened by the occurrence in a nearby Laguna Niguel site representing the later phase of the Late Miocene Section of the Monterey, of a tibiotarsus seemingly assignable to D. californica.

A tie-in with the Tepusquet Canyon exposures of the Monterey and the Santa Monica Mountains exposures of the Modelo Formation, as well as with the late phase of the Southeast Los Angeles Basin Monterey Formation avifaunas, is indicated by the occurrence at LACM Loc. 1945 of a fragment of the "toothed" jaw bone of Osteodontornis.

Other identified avian species from LACM Loc. 1945 include holotypes of Fulmarus hammeri Howard, 1968, Aethia rossmoori Howard, 1968, Alcodes ulnulus Howard, 1968 and Praemancalla lagunensis Howard, 1966. None of these species has been recorded elsewhere. Alcodes and Praemancalla are new genera assigned to the Mancallinae, an extinct subfamily of the auks (Alcidae). Alcodes has not been found elsewhere. A second species of Praemancalla ^{P. wetmorei Howard, 1978} occurs in the later phase of the Monterey Formation at Laguna Niguel. The genus is considered as possibly ancestral to the flightless auk, Mancalla, which occurs abundantly in Pliocene marine deposits especially in southern California.

{ and is tentatively recognized in the lower level of
the San Mateo Formation in San Diego County (LACM Loc. 4297)
still under study.

LACM locality 1945 has produced several unidentified species of odontocete and mysticete Cetacea, as well as a periotic of the otherwise middle Miocene *odontocete* (see Barnes, 1976:330, table 4; 1978:6).
 , Liolithax kernensis Kellogg, 1931. The species is represented by many individuals from the Sharktooth Hill Bonebed faunule and is probably a relict in the Monterey Formation in Orange County. Additional middle Miocene holdovers are the amphibious subungulate Desmostylus and the *allodesmine* pinniped Allodesmus. Both are represented at LACM locality 1945 by isolated teeth.

The two pinniped species ^{that are} known from the Sisquoc Formation are apparently ^{also} present at LACM locality 1945. A few bones of a small arctocephaline otariid agree with bony impressions of the holotype of Pithanotaria starri. Some isolated teeth closely match those of the holotype of the large pinniped Imagotaria downsi, but other large teeth seem to represent another species. Other isolated teeth are identified as the dugongid (see Domning, 1978:fig. 14j-1) Dusisiren sp. A, and this diagnostic trio of late Miocene mammals therefore is associated at LACM locality 1945.

LACM localities 3185, 3510, 3541, 6901, 6902, 6903, 6904, 6905, 6906 and 7136 to the south of LACM locality 1945 near Aliso Creek in Laguna Niguel apparently represent the youngest (and therefore supposedly stratigraphically highest) part of the Monterey Formation in the area. They have marine vertebrate faunules slightly different than those from LACM locality 1945 and associated localities, and occur in beds of diatomaceous shale and siltstone overlain and in part interfingered with beds of clean white and silty yellow sand. Most of the fossils are well preserved and some are articulated or associated skeletons. Some of these localities were discovered in 1969 during construction of an electronics factory and nearby associated road cuts. Fossils had been reported in the area considerably earlier than then however (Downs, 1955:LACM locality 1101).

In the absence of good outcrops and positive stratigraphic data relating these localities to the presumably older LACM locality 1945, the age difference has been suggested by the differences in faunal content. With the exception of one abraded cusp fragment of uncertain locality provenience, Desmostylus has never been found at these localities, but Dasisiren jordani (Domning, 1978:21, *et seq.*), Imagotaria downsi, and Pithanotaria starri (Barnes and Repenning identifications) have been found, and this association of three mammals also characterizes the upper part of the Santa Margarita Formation in Scotts Valley. here Desmostylus and Paleoparadoxia have been recorded from the lower, probably early Clarendonian part of the formation and not from the upper part (Mitchell and Repenning, 1963:9, 12). As yet, however, no

desmostylians have been collected in the upper part of the Santa Margarita Formation contrary to the suggestion of Mitchell and Repenning (1963:13).

The bird species, Praemancalla wetmorei Howard, 1976, which has been published from the supposedly younger section of the Monterey Formation (LACM localities 3185, 6902, 6906) reaffirms the age separation suggested by the mammals. Praemancalla lagunensis Howard, 1966 is known from LACM locality 1945 where it is definitely associated with Desmostylus, and Praemancalla wetmorei from the apparent later horizons is a more derived species than P. lagunensis (see Howard, 1976:146).

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Fourteen avian species have been found at five of the localities (LACM 3185, 6901, 6902, 6906 and 7136) in the higher part of the Monterey Formation in Laguna Niguel (Howard, 1978). All are known by disassociated (usually fragmentary) bones. The ^{span} age separation within the Monterey formation suggested by the mammals is reaffirmed by the birds. Praemancalla wetmorei Howard, 1976 from the younger section (at localities LACM 3185, 6902 and 6906) shows greater specialization for wing-propelled diving than does Praemancalla lagunensis which is associated with Desmostylus in the older section at locality LACM 1945.

Of the Middle Miocene species typical of the ^{Barstovian age} Sharktooth Hill Bonebed, which were recorded from locality LACM 1945, Puffinus ?priscus, Presbychen abavus and Diomedea ?californica, only the latter is noted (tentatively) at locality LACM 6906.

Of the typical Late Miocene ^{species} forms, Morus lompocanus is recognized in localities LACM 6901, 6902 and 6906 (Howard, ¹⁹⁷⁸ op. cit.), and Miosula media (tentatively) in LACM 6906 and 3185. The specimen from locality 3185, a tibiotarsus (LACM 52217), was ¹⁹⁷⁸ previously referred to M. lompocanus (Howard, op. cit.), but comparison with a recently prepared latex mold of the type of Miosula media now suggests closer similarity to Miosula.

Osteodontornis orri is represented at locality LACM 6902 by an incomplete carpometacarpus which conforms precisely with the impression of this element in the holotype specimen from Tepusquet Canyon. Fragments of "toothed" jaws also occur at localities LACM 6902 and 7136.

The remaining identified ^{bird} species from the Laguna Niguel (Howard, op. cit.) ¹⁹⁷⁸ sites are newly described: a shearwater, Puffinus barnesi;

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a very large gannet-like sulid, Morus magnus; and Gavia brodkorbi, the earliest record of the loons on the west coast. Other fragments suggest an undescribed species of petrel (Oceanodroma), and several alcids. One of the latter, referred tentatively to the genus Uria Brisson 1760, is the first record of the Murres from the Tertiary of western North America. The genus has since been recognized in the Sisquoc Formation and in the lower level of the San Mateo Formation, but the material from these localities is still under study and the species are undetermined.

Downs (1955) identified an otariid skeleton (LACM 1404) from one of the Laguna Hills localities high in the Monterey Formation (LACM 1101) as cf. Allodesmus kernensis, a middle Miocene (Barstovian correlative) species. The specimen is actually Imagotaria, probably I. downsi (Barnes re-identification) and its humerus and ulna can be matched by specimens referred to that species from other nearby sites in the Monterey Formation (LACM localities 6901, 6902, 6903, 6909) and from the Santa Margarita Formation in Scotts Valley (Repenning and Tedford, 1977). These other specimens from the Monterey Formation include skull parts, teeth, and limb bones representing several individuals, some of which are articulated. Some of these specimens referred to Imagotaria downsi compare well with elements of the holotype (SBMNH 342) from the Sisquoc Formation. locality?

Pithanotaria starri is represented by many 3-dimensional bones from Laguna Niguel. The holotype ^{from the Soguer formation} is represented only by impressions. Elements referred to this species (Barnes and Repenning identifications) include skull and jaw parts, limb elements, etc. The species appears to be equal in abundance with Imagotaria downsi and the two are commonly found associated in the same rocks (Repenning and Tedford, 1977).

One of the cetaceans is a primitive dolphin identified as the same new species of Pithanodelphis⁹⁵ recorded from the Modelo Formation. ^(L. from La 1230) The new species is known from nearly the complete skeleton and from several individuals collected at the Laguna Hills sites. The possibility exists of using the genus Pithanodelphis as an interocean indicator fossil for late Miocene time. ^{Many of} The other cetacean fossils from these localities are undiagnostic or are unidentified. One exception is a periotic that resembles the periotics in a large sperm whale skull collected from the Sisquoc Formation at Lompoc and displayed at the Santa Barbara Museum of Natural History.

Terrestrial vertebrates from the sites include a toad, the rabbit Hypolagus, a sciurid, and an antilocaprid. These are all represented by isolated postcranial bones.

Most of the teleosts and chondrichthians come from the sand beds within the shales in the Monterey Formation. ^{at localities ??}
 Very few ^{fish} specimens have been found in the diatomaceous shales. Sand deposits, such as those in the Laguna Hills outcrops of the Monterey Formation suggest *depositional* conditions different from the diatomites of the Sisquoc Formation and other deep water rock units, including the shales in the Monterey at Laguna Hills. Correspondingly, the teleost faunas differ. Tropical or subtropical forms, such as the puffer fish, Diodon, the triggerfish, Balistes, and the parrot fish are abundant in the Barstovian-correlative Round Mountain Silt of ^{and similar aged rocks in Orange County and} Bakersfield and have their last California fossil records in the sites at Laguna Hills.

Locality.—LACM loc. 1945 (= UCMP loc. V71020), Laguna Hills, Orange Co. NW side of Avenida Majorca, Leisure World; SW ¼ NE ¼ SW ¼ S. 34, T6S, R8W, San Juan Capistrano Quadrangle (7.5', 1968).

GEOLOGY: Specimens from coarse loose sand and gravel, underlain by dense orange clay and overlain by dense gray clay, about 70' below original hilltop and dipping slightly E.

FORMATION: Monterey Formation, near (unconformable) contact with overlying Capistrano Formation (Vedder et al., 1957; Morton et al., 1974); in lower Monterey, within 100 stratigraphic feet of a limestone at the base of the Monterey (L. G. Barnes, pers. commun.).

SIRENIAN MATERIAL: LACM 41014: Fragment of left scapula. Coll. W. E. Calhoun, Dec. 19, 1964. LACM 41015-6: Rib fragments. Coll. E. D. Mitchell and party, Aug. 27, 1964; Explorer Post 806, Dec. 19, 1964. LACM 41017: (juvenile) Symphysis of left mandible. Coll. M. K. Hammer, Dec. 1964. LACM 41018-22: Rib fragments. Coll. Weiderts and Leavell, 1964. LACM 41023-6: Rib fragments, tooth fragment, neural spine, rib fragment. Coll. M. K. Hammer, Dec. 1964. LACM 41027-34: Rib fragments. Coll. Weiderts and Leavell, 1964. LACM 41035-40: Rib fragments. Coll. M. K. Hammer, Dec. 1964. LACM 41042: Rib fragment. Coll. E. D. Mitchell and party, Aug. 27, 1964. LACM 56837-8: ?DP₃ and left ?M₁. Coll. LACM party, ca. 1964. LACM 56839: Right ?M₁. Coll. M. K. Hammer, Dec. 24, 1964. LACM 56840-2: ?DP₂s. Coll. LACM party, 1964. LACM 60698: (juvenile) Fragment of right exoccipital. Coll. LACM party, 1964. UCMP 94334-5: (juvenile) Parietal-supraoccipital and rib fragments. Coll. L. G. and W. H. Barnes, Dec. 19, 1964. All referred to *Dusisiren* sp.; described with material of *D. jordani*.

ASSOCIATED FAUNA: *Isurus hastalis*, *I. planus*, *Carcharodon megalodon*, *Carcharinus*, *Myliobatis*; *Makaira* sp. (Fierstine and Applegate, 1968); Teleostei; *Psephophorus* (det. L. G. Barnes); *Puffinus calhouni* (holotype), *Osteodontornis orri*, cf. *Morus lompopanus*, *Praemancalla lagunensis*, and other birds (Howard, 1968); *Allodesmus*, cf. *Pithanotaria*, *Imagotaria* cf. *downsi* (det. L. G. Barnes); *Desmostylus*.

AGE AND CORRELATION: Smith (1960) placed the lower Monterey Fm. of this area in the *Siphogenerina collomi* zone (upper Luisian), but there are discrepancies between the foraminiferal age assignments and the marine vertebrate evidence (see Section III[12]). A Mohnian age for this locality seems quite possible.

Locality.—LACM loc. 6906J, Autonetics plant, 5 mi. SSW of El Toro, Orange Co. On S spur of 320' hill between Aliso Creek and unnamed eastern tributary; now under factory building, at foundation post no. F-26½, 75' S of NW end of building; elev. 217'. San Juan Capistrano Quadrangle (7.5', 1968).

GEOLOGY: Bones in 6'-8'-thick bed of yellow-orange silty sand.

FORMATION: Mapped as Monterey Formation (Vedder et al., 1957; Morton et al., 1974); probably upper Monterey (L. G. Barnes, pers. commun.).

SIRENIAN MATERIAL: LACM 23847: (juvenile) Nearly complete skull with periotics, tympanics, mallei, incudes, right M₁, left ?DP₄, M₁; parts of mandibles with one DP₂, right DP₂, left DP₄; parts of atlas, axis, one or more cervicals, at least 16 precaudal vertebrae including lumbar and sacral, 11 caudals, 6 chevrons; part of at least 17 right and 13 left ribs; part of manubrium; left humerus; right and left innominates. Coll. M. J. Bohrer, W. E. Calhoun, and S. P. Applegate, Oct. 20, 1969. Referred to *Dusisiren jordani*.

ASSOCIATED FAUNA: *Cetorhinus*, *Isurus*, Teleostei (det. B. Welton); *Pithanotaria starri*, *Imagotaria downsi*, aff. *Pithanodelphis*, Physeteridae, Cetotheriidae (det. L. G. Barnes).

AGE AND CORRELATION: Though Smith (1960) assigns the upper Monterey Fm. to the lower Mohnian, the seemingly advanced stage of evolution of the sirenian suggests a later, perhaps Delmontian, date (see Section III[12]). That this site is younger than LACM loc. 1945 (above) is also supported by the absence of *Desmostylus* and the presence of more advanced pinnipeds (true *Pithanotaria starri* and *Imagotaria downsi*; L. G. Barnes, pers. commun.).

Locality.—LACM loc. 3541, Moulton Ranch, 2 mi. SSW of Laguna Hills, Orange Co. On SW side of summit of 480' hill between two western tributaries of Aliso Creek. San Juan Capistrano Quadrangle (7.5', 1968).

GEOLOGY: Section from S. P. Applegate's field notes, Jan. 16, 1965:

Sands	50 feet	More brown and orange silts	30 feet
Diatomaceous earth	20 feet	Hard sandstone	
Yellow sands and silts (mammal remains)	6 feet		

FORMATION: Mapped as Niguel Formation (Vedder et al., 1957; Morton et al., 1974); the maps show the approximated Monterey-Niguel contact about 60' below loc. 3541. More likely upper Monterey Formation.

SIRENIAN MATERIAL: LACM 28454: (adult) Fragments of ?periotic, some caudal vertebrae and numerous ribs; parts of scapulae, humeri, radii, and ulnae; right scaphoid-lunar-centrale and metacarpal III. Coll. P. Kramer, L. Fox, and LACM parties, Jan. 10, 16, and 18, 1965. Referred to *Dusisiren jordani*.

ASSOCIATED FAUNA: None.

AGE AND CORRELATION: LACM loc. 3185, at the base of the hill roughly 100' below 3541 in beds mapped as Monterey, contains a fauna (*Isurus*, Teleostei, Chelonia, Aves, Odontoceti, cf. *Imagotaria*) similar to that found at loc. 6906 and nearby localities. The possibly advanced stage of evolution of LACM 28454 is consistent with correlation with loc. 6906 or a slightly higher horizon in the Monterey Fm., but assignment to the Late Pliocene Niguel Fm. is in conflict with all other data on stratigraphic occurrence of North Pacific sirenians.

(Downing, 1978: 156-157)

Valmonte Diatomite Member

The Valmonte Diatomite Member of the Monterey Formation (Woodring, Bramlett, and Kleinpell, 1936) is exposed in the Palos Verdes Hills, Los Angeles County. Fossils were found near Lomita in the commercial diatomite quarries of the Dicalite Company and later of the Great Lakes Carbon Corporation (Wright, Chesterman, and Norman, 1954:69, 73), and include mammals, birds and fish.

Lyon's (1941) tentative identification of an incomplete skeleton of a sea lion (LACM 4324) from this rock unit, as Pontolis magnus True, 1906, was later questioned by Mitchell (1968:1879-1880). He found several similarities with Imagotaria. Although he did not identify the specimen, he concluded that it was related to Imagotaria downsi. Large bones, resembling elements in the skeleton of LACM 4324, have been found in Laguna Hills at sites that have produced specimens identified as I. downsi, and it is probable that LACM 4324 is actually I. downsi. A unique type of primitive harbor porpoise, Loxolithax stocktoni Wilson, 1973, has been described from the Valmonte Diatomite, and at least two individuals of the species have been found (Barnes, in press). These were probably the same fossils referred to by Miller (1935:78) as small cetaceans similar to Lagenorhynchus. Caudal vertebrae of an unidentified small odontocete from San Pedro were labeled as "Phocaena occidua" by Jordan and Gilbert (1919a:59, pl. 9, fig. 2), and may have been collected from the Valmonte Diatomite Member of the Monterey Formation, however, the specimen was said to be preserved in a "friable sandstone shale".

Four species of birds have been recognized from the Valmonte Diatomite Member at Lomita: Puffinus diatomicus, ?Sula willetti, Palaeosula stocktoni (Miller, 1935:75, holotype), and a small albatross given only the generic assignment, Diomedea (Miller, 1935:79). Each taxon is represented by an incomplete fossil skeletal impression with some bone still present.

The Puffinus diatomicus record (Howard, 1955:14) is based on a specimen that the owner of the Dicalite mine in Lomita preferred to keep as a

?
caudal
vertebrae
OR
"The slab
contains
The vertebrae
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wall decoration for his office (Loye Miller, correspondence). The tentative referral (Howard, 1958:10) for Sula willetti was necessary in view of the possibility of identity with Sula pohli from the San Fernando Valley Modelo, rather than the species from Lompoc. Palaeosula stocktoni is known from only one other locality, the Modelo Formation at El Sereno.

Puffinus diatomicus is also recorded (Miller, 1935:74) from the San Pedro breakwater exposure of Valmonte diatomite. This specimen, like the type from the Sisquoc Formation ^{at} Lompoc, is an imprint with no bone remaining.

VALMONTE DIATOMITE Birds

Four incomplete skeletal impressions, ^(with some bone adhering) representing four species of birds, ~~are recognized from the Valmonte diatomite at Lomita~~

the holotype of Palaeosula stocktoni (Miller, 1935), UCMP 32105, and referred specimens of Puffinus diatomicus, ?Sula willetti and a small albatross given only the generic assignment, Diomedea sp. (Miller, 1935:79).

Palaeosula stocktoni is a large sulid with relatively long humerus and short ulna. It is known from only one other locality, the Modelo Formation in El Sereno, where a single humerus was recorded (Howard, 1958).

The Puffinus diatomicus record (Howard, 1955:14) is based on a specimen that the owner of the Dicalite mine in Lomita preferred to keep as a wall decoration for his office (Loye Miller correspondence).

UCMP
no?

The tentative referral for Sula willetti is based on obverse and reverse slabs with impression of incomplete leg and wing bones (UCLA 2543). The general size of the specimens is comparable to both S. willetti and S. pohli. The proportions of ulnar to humeral length that distinguish the two species cannot be accurately ascertained, but other characters seem to favor assignment to S. willetti.

UCLA no?

In the albatross specimen (UCLA ^{2821, 2822} ~~2823~~) the carpometacarpus is best represented. It agrees in size with an unrecorded albatross carpometacarpus recently collected from LACM locality 6902 in the Monterey Formation of Orange County, and suggests a distinct species whose size falls between the large Diomedea californica Miller, 1962 and the very small D. milleri Howard, 1966, both described from the Sharktooth Hill Bonebed of Middle Miocene, Barstovian correlative, age.

#? A specimen of Puffinus diatomicus (leg bones only) was recorded by Miller (1935) from the "San Pedro Breakwater." The description of the site indicates that the specimen came from the Valmonte diatomite in cliffs adjacent to the present Cabrillo Beach Museum. Also collected at the Cabrillo Beach site, though still unrecorded, is a small alcid about the size of Aethia rossmoori Howard, 1968, described from LACM locality 1945 in the Monterey Formation of Orange County. A large portion of the skeleton is present on the slab of diatomite, but few detailed characters remain. The coracoid resembles coracoids taken at LACM locality 1945 which are doubtfully of A. rossmoori.

Fragmentary specimens in LACM from the vicinity of Pomona and Covina represent at least three types of odontocete whales. Of these, one is a small sperm whale and one ^{possibly} a pontoporiid dolphin. The third type appears to represent Loxolithax stocktoni, ^{Member of the Monterey Formation} also known from the Valmonte Diatomite (see Wilson, 1973). The specimen is a fragment of maxilla from near Pomona (LACM Loc. 3331), and bears teeth and impressions of teeth with short, expanded crowns as seen on the holotype of L. stocktoni.

From diatomites also called ^{the} Puente Formation near Covina (LACM Locality 1147) has been collected a cheek tooth of a horse identified as Hipparion mohavense Merriam by Stock (1928). This tooth was the only vertebrate paleontological evidence bearing on the age of the Puente Formation at the time of Stock's (1928) writing, and suggests a correlation with the Ricardo Formation of the Mojave desert and with other Clarendonian ^{age} deposits. H. mohavense has also been found in the Santa Margarita Formation at Scotts Valley, in the Moraga Formation in the Berkeley Hills, and in the North Tejon Hills local fauna from the Chanac Formation of Montediablan age in the Tejon Hills.

CONCLUSIONS

There is a distinctive ^{assemblage of} late Miocene fossil marine vertebrate ^{species} ~~assemblage~~ ^{that} which lived in [✓] of the ^{several} depositional basins present at this time along at least 360 miles of the Pacific coast of present-day California. ^{rock units containing the vertebrate fossils} ~~All~~ The ~~localities~~ can be dated by associated fossils representing one or more of the following established stage-ages: Clarendonian ^{North American land} ~~terrestrial~~ ^{the} mammal age, [✓] "Margaritan" mega-invertebrate stage, and ^{the} Mohnian and Delmontian ^{benthic} foraminiferal stages.

L or Clarendonian-correlative aggregate

The Late Miocene marine vertebrate assemblage was preceded by a ^{fossil} marine vertebrate ^{assemblage} of Middle Miocene age which correlates with the Barstovian/^{North American} land mammal age, the late part of the provisional "Temblor" mega-invertebrate stage, and the Relizian and Luisian/^{benthic} foraminiferal stages (see Savage and Barnes, 1972:133, 140-141, fig. 3; Addicott, 1970:34-35). ^{Localities that produce this} latter assemblage are less abundant than those of late Miocene age, and the bulk of our knowledge of the Middle Miocene vertebrates comes from the Sharktooth Hill Bonebed faunule in the Round Mountain Silt in Kern County. That faunule ^{has a} distinctly warm water aspect on the basis of the sharks, turtles, teleosts, and birds. ^{Most} Other published records of Middle Miocene marine vertebrates are isolated occurrences in such rock units as the Temblor Formation.

An apparently distinctive marine vertebrate assemblage follows that of the late Miocene, and can be correlated directly with the "Jacalitos" and "Etchegoin" provisional mega-invertebrate stages (Sensu Addicott, 1972:15-17, fig. 2) and indirectly with the Hemphillian ^{Land} North American Mammal Age. It probably ranges in age from about 10 million years to at least 5 million years ago (Berggren and Van Couvering, 1974: fig. 11) and is ^{now} correctly called latest Miocene in age, but in western North American paleontological literature was traditionally called Early Pliocene. The ^{species of} sharks, teleosts, birds, and relative scarcity of turtles, suggest a cooler average water temperature than during the Middle Miocene, and the fossils come from such rock units as the Etchegoin, Jacalitos, Purisima, Capistrano, San Mateo, and Almejas Formations.

Regardless of earlier chronologies and positions of the Miocene-Pliocene boundary (cf. Weaver, et. al, 1944; Durham, Jahns, and Savage, 1954) Barron has placed that boundary in diatom biostratigraphy (1975:fig. 8) at about 5 million years ago (cf. Berggrenⁿ and Van Couvering, 1974), and at the top of the Nitzschia reinholdii concurrent-range Zone. The Nitzschia reinholdii Concurrent-range Zone, based on diatoms with its type section in the Sisquoc Formation near Lompoc, is also stated by Barron as correlative with the type section of the Bolivina obliqua Zone of Kleinpell (1938) based on foraminifera from the Modelo Formation on the north flank of the Santa Monica Mountains. This interval is also considered to be younger than the Mohnian benthonic foraminiferal stage (Barron, 1975:fig. 8) and older than the Repettian benthonic foraminiferal stage (Barron, 1976:122). It should be pointed out that in this context (Barron (1975:630; 1976:122) is deleting or modifying the concept of the Delmontian stage as defined in its type section.

In contrast to ^{usage}
~~Regardless of~~ earlier chronologies and positions of the

Miocene-Pliocene boundary (cf. Weaver, et. al, 1944; Durham, ^{, through corrections made possible by the}
 Jahns, and Savage, 1954) Barron has placed that boundary

in diatom biostratigraphy (1975:fig. 8) at about 5 million

years ago (cf. Berggrenⁿ and Van Couvering, 1974), and at the

top of ~~the~~ ^{the} ~~Nitzschia reinholdii~~ ^{North Pacific Diatom} concurrent-range Zone. The

Nitzschia reinholdii Concurrent-range Zone, based on diatoms

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out that in this context (Barron (1975:630; 1976:122) is

deleting or modifying the concept of the Delmontian stage as

defined in its type section.

the Pacific Diatom
 NPDZ 10a which is

Delmont ? I see no point.

Among the mammals, the pinnipeds Imagotaria downsi and Pithanotaria starri are conspicuous members of this assemblage and are not recognized in middle Miocene or Pliocene faunas. One record of Allodesmus indicates that this genus, characteristic of the middle Miocene marine vertebrate assemblage, persisted at least into the early part of the late Miocene as did the two desmostylians, Desmostylus and Paleoparadoxia, and the cetacean Liolithax. The sirenian Dusisiren jordani was perhaps one of the most abundant mammals of this fauna. Cetacean genera cf. Balaenoptera, aff. Herpetocetus, cf. Nannocetus, Megaptera, and Pithandodelphis are found in one or more localities, and, in varying degrees, are typical of this late Miocene marine vertebrate fauna. Mitchell & Repenning (1968: Table 1) show desmostylians living through the end of the Miocene to the end of the Neroly stage (= end of "Margaritan" stage), but not to the end of the Clarendonian. We suggest that desmostylians do not occur to the end of the "Margaritan" stage as Mitchell and Repenning recorded them, but that they ceased to exist at about the middle of that stage and about the middle of the Clarendonian age (see Domning, 1972:149).

The avian species in this assemblage are more numerous than the mammalian species. Bones of shearwaters and sulids are abundant and represent three or more species in each group. Both families are also well represented in California in the middle Miocene and continue on through the Pliocene and Pleistocene. Shearwaters are still abundant off the coast

of California and Mexico today; the sulids have moved southward, but are prolific in Mexican waters. A comprehensive review of these two groups (which should include eastern North American and European fossils as well as those here discussed) is greatly to be desired and should reveal some relationships that were impossible to ascertain as each individual occurrence was recorded.

Partly because of the variety of longer-lived bird species, the separate localities are less easily correlated using birds than the mammalian taxa. Furthermore all the mammals represent extinct genera, whereas less than half of the birds are generically extinct and are, therefore, more difficult to differentiate. Comparison between avian taxa is further complicated by the lack of comparably preserved material from the several localities (impressions versus fragmented, disassociated bones).

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1980
In spite of these difficulties, however, four bird taxa can be traced with reasonable certainty in at least three late Miocene localities: the shearwater, Puffinus diatomicus; two sulids, Morus lompocanus and Sula will-etti; and the bony-toothed Osteodontornis (see Table 1).

As in the case of Allodesmus and Desmostylus among the mammals, three birds appear to be holdovers from the middle Miocene: a shearwater, Puffinus priscus; a goose, Presbychen; and an albatross, Diomedea californica. One alcid, Praemancalla, is seemingly ancestral to the well-known Pliocene flightless auk, Mancalla.

INTRODUCTION

We wish to demonstrate that faunal assemblages of ^{fossil} marine vertebrates representing chronostratigraphic units of stage-age magnitude are recognizable and definable in the Neogene deposits of the Pacific coast of North America. To this end we provide an example: namely the ^{Late Miocene} marine vertebrate faunal unit that existed ^{from} about 10 to ³ $1\frac{1}{2}$ million years ago and is a temporal correlative of the Clarendonian North American Provincial ^{Mammal} Age, the ^{improperly defined} "Margaritan" (Addicott, 1972) west coast mega-invertebrate stage, and the Mohnian and Delmontian west coast foraminiferal stages. We do not now propose the naming or the establishment of sequences of formal marine vertebrate stages but point out that knowledge of fossil marine vertebrates has advanced to the point where they are useful in correlation. No geologic, evolutionary, or zoogeographic phenomena are defined which would necessarily separate the Clarendonian-equivalent marine vertebrate assemblage from previous or successive assemblages, however, to date (no transitional faunas have been noted and the late Miocene marine vertebrate fauna is distinct from earlier and later faunas.

? {
 ?
 ↓
Pracmancalla
 goes into San Mateo fm.
Desmostylus and possibly
Diomedea californica and
Puffinus pacificus + Barbycheilus abaxus
 are haldones from Bastonian
Osteodontornis is now found
 at Sharktooth Hill.

albatross, Diomedea californica. One alcid, Praemancalla, is seemingly ancestral to the well-known Pliocene flightless auk, Mancalla.

Along with the cetacean, Pithanodelphis, two birds, Osteodontornis and Microsula, suggest correlations with Atlantic faunas.

																						97																				
MIOCENE																		PLIOCENE		PLEISTOCENE	EPOCH																					
EARLY						MID	LATE																																			
AQUITANIAN				BURDIGALIAN			LAN- GHIAN		SERRAVALLIAN					TORTONIAN				MESSINIAN		ZANCHELLIAN		ASTIAN		CALABRIAN	MARINE MOLLUSK																	
N3		N4		N5		N6		N7		N8		N9		N10		N11		N12		N13		N14		N15		N16				N17		N18		N19		N20		N21		N22		PLANKTON
AQUITANIAN				BURDIGALIAN			VINDOBONIAN					MAREM- MIAN		VALLESIAN			TUROLIAN			RUSCINIAN			VILLA- FRANCHIAN			CROMERIAN		LARGE MAMMAL														
PAULHIAC		LAUGNAC			LA ROMIEU			SANSAN			LA GRIVE			SABADELL			TERUEL			PERPIGNAN								SMALL MAMMAL														
TAKIAN		OTAIAN			HUTCHINSONIAN			AWAMDAN		ALTON		CLIFF- DENIAN		LILLBURNIAN		WAIJAWAN		TONGAPO- RUTUAN		KAPITEAN			OPOITIAN			ET AL		NEW ZEALAND FORAM														
D		E				F1			F2			F3			G				H						INDONESIAN FORAM																	
NISHIKUROSAWA				ONNAGAWA					FUNAKAWA					KITAURA			WAIMOTO		SHIBATAKAWA			ET AL		JAPANESE INVERT.																		
ORRIAN		SAUCESIAN					RELIZIAN		LUI- SIAN		MOHNIAN			DELMONTIAN			REPETTIAN		VEN- TURI-		WHEELERIAN					EAST PACIFIC BENTHON FORAM																
VAQUEROS		TEBLOR					BRIONES			CIERBO NEROLY			JACALITOS			Etche- goin		SAN JOAQUIN					PACIFIC MOLLUSK																			
ARIKAREEAN				HEMINGFORDIAN				BARSTOVIAN				CLARENDONIAN			HEMPHILLIAN					BLANCAN ET AL				N. AMER LAND MAMMAL																		
SPILDOVIAN								HOMERIAN				CLAUDULCHIAN										N.A. PLANT.																				

EPOCH

MARINE MOLLUSK

PLANKTON

LARGE MAMMAL

SMALL MAMMAL

NEW ZEALAND FORAM

INDONESIAN FORAM

JAPANESE INVERT.

EAST PACIFIC BENTHON FORAM

PACIFIC MOLLUSK

N. AMER LAND MAMMAL

N.A. PLANT.

Figure 3. Suggested correlations of important Miocene marine vertebrate faunas in California.

	Land Mammal Ages	Mega- invertebrate Stages	Benthic Foraminiferal Stages	
MIOCENE	Hemphillian	Jacalitos	Repettian	
	Clarendonian	Neroly	Delmontian	Sisquoc Fm., Santa Margarita Fm., <u>El Toro</u> localities
		Cierbo	Mohnian	
		Briones	Luisian	
	Barstovian	Temblo	Relizian	Sharktooth Hill Bonebed and correlative localities
	Hemingfordian		Saucesian	Pyramid Hill and Willow Springs localities
	Arikareean	Vaqueros	Zemorrian	

? Orange County?
Monterey fm

Savage and Barnes, 1972:12.

TABLE 1.—Time correlation chart

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TIME (m.y.)	AGE (this report)		EUROPEAN STAGES	NORTH AMERICAN MAMMALIAN AGE	WEST COAST MARINE STAGES		WEST COAST USAGE	NOTES
					MEGAFOSSILS ⁶	MICROFOSSILS		
1	PLEISTOCENE	Late	Calabrian	Rancho-labrean ¹		Delmontian	Pleistocene	¹ Berggren and Vancou- ering, 1974. For excep- tions see text.
2		Early		Irvingtonian ²			Early	
3	PLIOCENE	Late	Astain Placenzian Zandian	Blancan ³	"Etchegoin" and "San Joaquin"	Base <i>Bolivina obliqua</i> zone	PLIOCENE	² Addicott, 1972, 1969.
4		Early					Late	
5	MIOCENE	Late	Messinian	Hemphillian	"Jacalitos"	Mohnian	PLIOCENE	³ Naeser, Izett, and Wilcox 1971. Johnson, Opdyke, and Lindsay, 1972: based upon the earliest <i>Lepus</i> .
6								
7		Early	Tortonian	Clarendonian	"Margaritan"		Early	⁴ Evernden and others., 1964.
8								
9		Middle	Serravallian	Barstovian	"Temblor"	Luisian ⁸	Late	⁵ Oldest Hemphillian date 8.0 m.y. Ash Hollow Formation, J.D. Boeli- storf, written commu- nication to Tedford, 1975.
10								
11		Early	Langhian	Hemingfordian	"Vaqueros"	Relizian ⁸	Middle	⁶ Pierce, 1970, Barron, 1976: temporal over- lap of definitions are involved.
12								
13		Late	Burdigalian	Arikarean		Saucesian	Early	⁷ Turner, 1970, KA2127 Barstovian mammals just below, unpublished.
14								
15	OLIGOCENE	Early	Aquitania			Zemorian ⁸		⁸ Turner, 1970.
16								
17								
18								
19								
20								
21								
22								
23								
24								

middle-late Miocene boundary falls at approximately 11 m.y., postdating the oldest radiometrically dated record of the horse genus *Hipparion* in Europe, which has been dated at 12.4 m.y. (Lippolt and others, 1963: Howenegg fauna of Germany). In

North America the change from the Barstovian to the Clarendonian mammalian ages, marked by the first record of *Hipparion*, also was about 12 m.y. ago (Evernden and others, 1964).

The beginning of middle Miocene is selected to

Repenning and Tedford, 1977:4.

RENNING and TEDFORD, 1972: m.s.

TABLE I

10 ⁻⁶ YEARS	EPOCH	THIS PART Report	EUROPE STAGES	NORTH AMERICAN MAMMAL AGES	CALIFORNIA STAGES PROVINCIAL MARINE		WEST COAST USAGE		ANNOTATIONS
					MEGA (12)	MICRO	SPOON	PART	
1	PLEISTOCENE	L	CALABRIAN ET SEQ.	R. L. B. (4)			PLEISTOCENE		1) Berggren, 1972.
2		M		IRVING- TONIAN (5)					2) Van Couvering and Miller, 1971; Van Couvering, 1972.
3		E		BLANCH (3)					3) Savage and Curtis, 1970; Lamb and Beard, 1971.
4	(3) PLEISTOCENE	PLIOCENE	ASTIAN PIACEUZIAN (2) ZANCLIAN	(6)	"ETCHEGON" and "SAN JOAQUIN"		PLIOCENE		4) Hawby and Firby, 1973.
5									5) Naeser, Izett, and Wilcox, 1971; Johnson, Opdyke, and Lindsay, 1972.
6	E	LATE	MESSINIAN (2)	HEMPHILLIAN (2)	"JACALITOS"		PLIOCENE		6) Evernden et al, 1964.
7									7) Oldest Clarendonian date > 11.5 my (6.) but lowered to accommodate Lippolt et al, 1963.
8									Youngest Barstovian date 12.3 my (6.).
9	N	EARLY	TORTONIAN (2)	CLAREN- DONIAN (6)	"MARGA RITAN"	DELMOGIAN (10) MOHAWK	LATE		8) Oldest Barstovian date > 16.2 my Silberman and McKee, 1972.
10									9) Turner, 1970.
11	E	MIDDLE	SERRAVALLIAN (1)	BARSTOVIAN (7)	"TEMBLO"	LUSITAN (9) RELIZ- IAN (9)	MIDDLE		10) Pierce, 1970.
12									11) Obradovich, 1968.
13									12) Addicott, 1972.
14	O	EARLY	BURDI- GALIAN (1)	HEMINGFORDIAN (8)	"VAQUEROS"	SAUCESIAN (9)	MIDDLE		13) Berggren, 1971.
15									
16	M	EARLY	AQUITANIAN (1)	ARIKAREAN (6)			EARLY		
17									
18	C	EARLY							
19									
20	O	EARLY							
21									
22	M	EARLY							
23									
24	UNICO- CENE								

TABLE I: - Correlation of Stages and Ages used in this report

WEST COAST RENTHONIC FORAMINIFERAL		WEST COAST MEGA-INVERTEBRATE	N. AMERICAN LAND MAMMAL	FAR EAST LETTER STAGES	SIRENIAN RANGE ZONES	Orange Co.	Los Angeles Co.	Santa Barbara Co.	Kern Co.	San Luis Obispo Co.	Santa Cruz Co.
M.Y.A. EPOCH	STAGES	"STAGES"	"AGES"								
5	P L E I S T	"HALLIAN"		RANCHOLABREAN	HG						HG
				IRVINGTONIAN			Lomita Marls				↑ ?terrace deposit, ca.
	P	"WHEELERIAN"	SAN JOAQUIN	BLANCAN	2					Squire Mbr.	19,000 B.P. (Wisconsinian)
	L	"VENTURIAN"			H 1	Niguel Fm.				Pismo Fm. HC	
	O		ETCHEGOIN								
10	C			HEMPHILLIAN		HC					
	E	REPETTIAN	JACALITOS				Capistrano Fm.				basal Purisima Fm. DD
		DELMONTIAN	NEROLY		DD		Towsley Fm. or Modelo Fm. DJ	Sisquoc Fm. DJ	Santa Margarita Fm. DB	Santa Margarita Fm. s	Sta. Cruz Mudstone
			CIERBO	CLARENDONIAN	DJ	DJ					Santa Margarita Fm. DJ
		MOHNIAN	BRIONES			Monterey Fm. D				lower Pismo Fm. DB	
15	M				DB	DA					
	I	LUISIAN		BARSTOVIAN							
		RELIZIAN	TEMBLOR		DA						
	O						lower Topanga Fm.				
	E	SAUCESIAN	VAQUEROS-TEMBLOR TRANSITION ZONE	HEMING-FORDIAN	DR	DA					
20											
25											
25	O			ARIKAREAN							
	L	ZEMORRIAN	BLAKELY-VAQUEROS								
25	I										
	G										

Fig. 28. Correlation chart of sirenian-bearing rocks in the North Pacific region. Each sirenian-bearing unit has been independently correlated (see Appendix I) with one or more provincial chronologies to determine range zones of the sirenian taxa; the correlations, with the exception of the Mio-Pliocene Orange County localities, are not based on the sirenians themselves. Temporal extents shown for stratigraphic units and sirenian range zones are the maximum considered allowable on basis of data herein presented. Vertical-line patterns symbolize uncertainty in placement of stage-age boundaries. Position of Miocene-Pliocene boundary used here approximates that traditionally recognized by West Coast stratigraphers. The Briones, Cierbo, and Neroly "Stages" are sometimes grouped into a single "Margaritan Stage." D, *Dusisiren* sp.; DA, *Dioplotherium allisoni*; DR, *Dusisiren reinharti*; DB, *Dusisiren* Species B; DJ, *Dusisiren jordani*; DD, *Dusisiren* Species D; H, *Hydrodamalis* sp.; HC, *Hydrodamalis cuestas*; HG, *Hydrodamalis gigas*; s, unidentified sirenian.

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FIGURE LEGENDS

Fig. 1. Locations of important areas in California (indicated by circles) which have produced late Miocene (Clarendonian correlative) marine vertebrate assemblages: 1-Lompoc Hills, Sisquoc Formation; 2-Scotts Valley-Santa Cruz, Santa Margarita Formation; 3-Tejon Hills, Santa Margarita Formation; 4-Humphreys Station, Towsley Formation; 5-Santa Monica Mountains, north slope, Modelo Formation; 6-Palos Verdes Hills, Valmonte Diatomite; 7-Tepusquet Canyon, Monterey Formation; 8-Laguna Hills, Monterey Formation; 9-San Gabriel Valley, Puente Formation.

Fig. 2. Correlation chart showing important rock units that have yielded Clarendonian correlative, late Miocene fossil marine vertebrate assemblages.

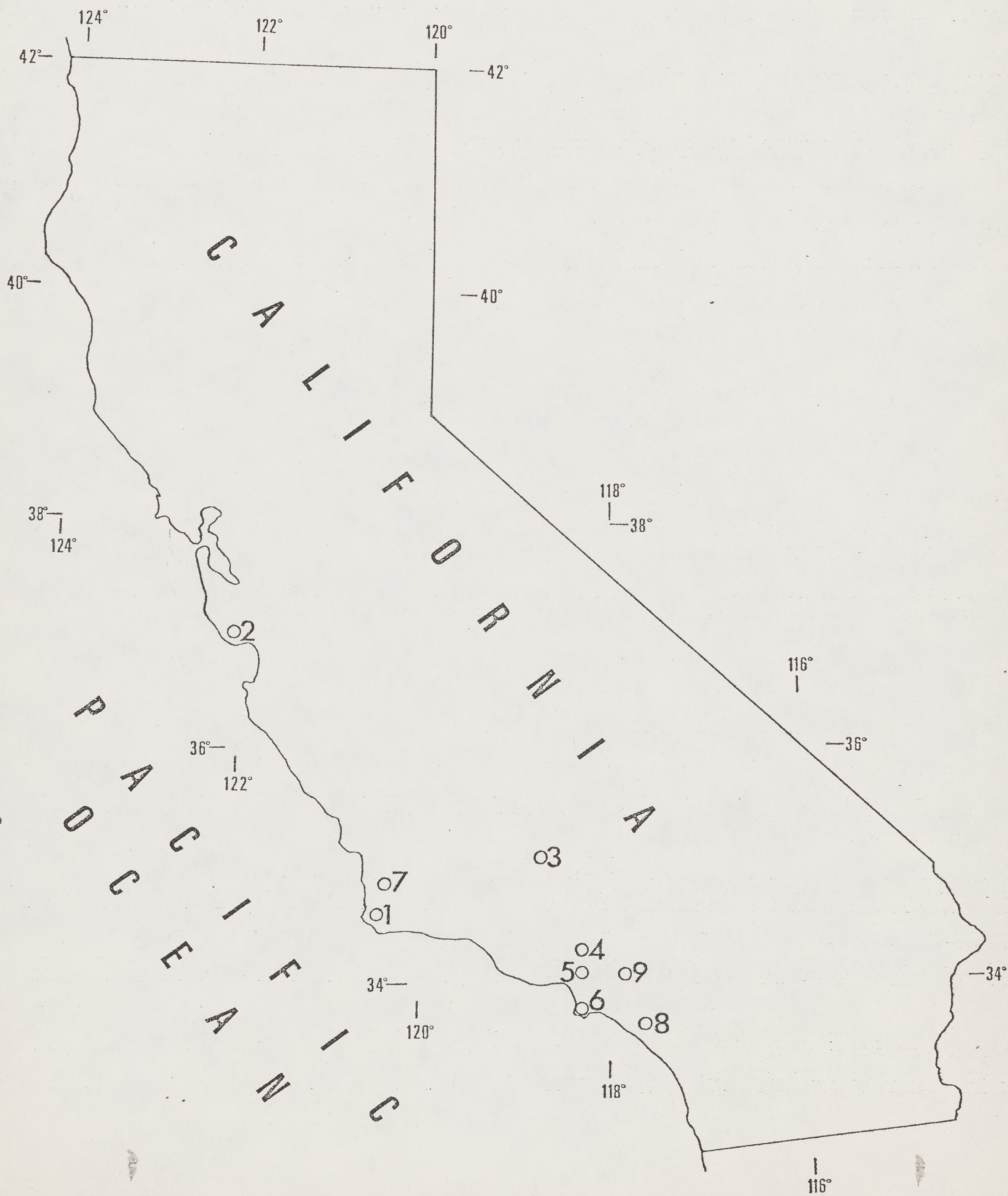


Fig. 2. Checklist of 110
 species rare to x. from Clarendonian-
 Correlative localities in California

[illegible]

Logana
HillsScotts
Valley
S. Marg.Tehon Hills
S. Marg.
ChanaeSan Gabriel
ValleySan
Gabriel
Mts.

Lompoc

